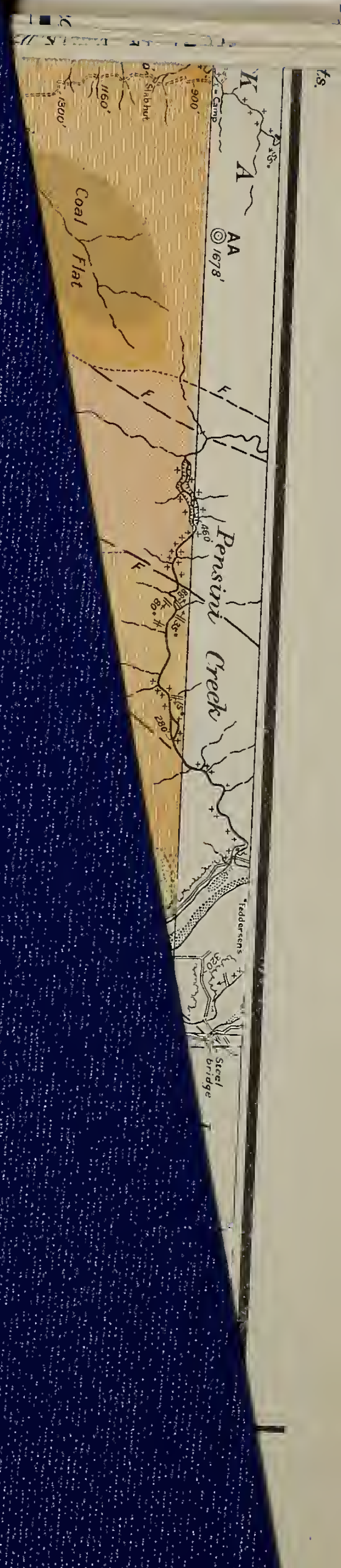
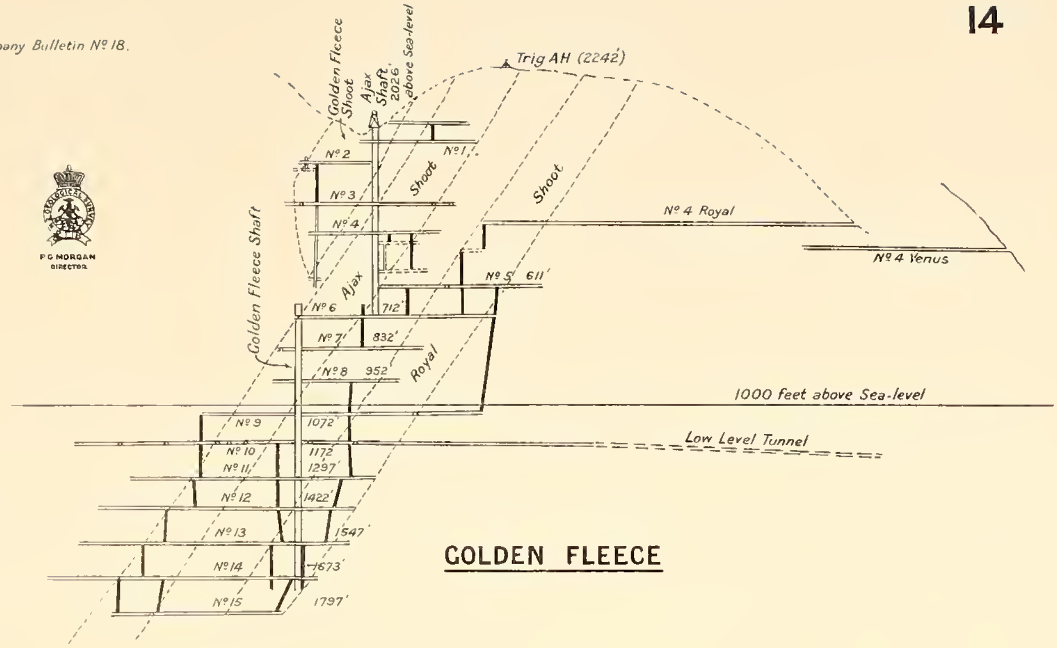
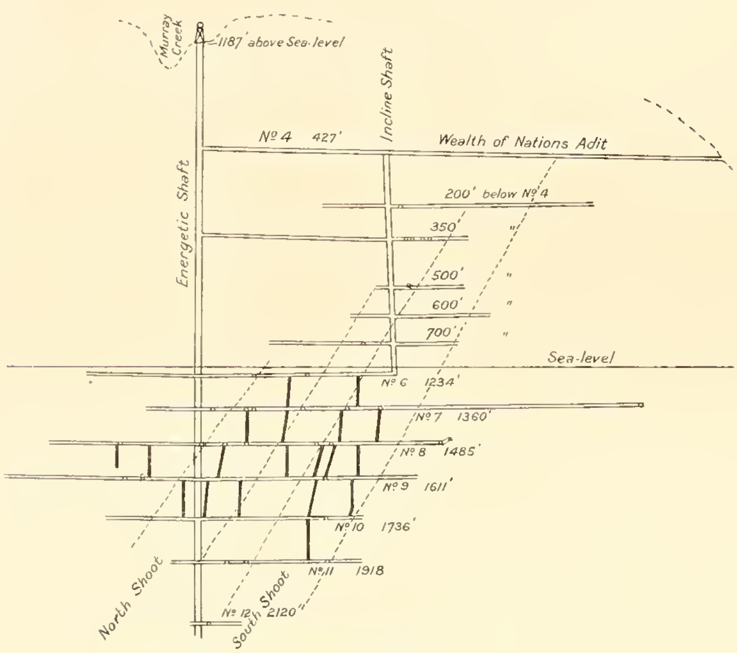

AA
1678'
Coal Flat
Pensini Creek
Steel bridge

To accompany Bulletin Nº 18.

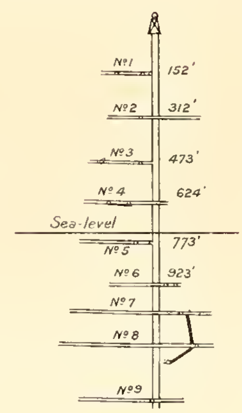
P G MORGAN
DIRECTOR



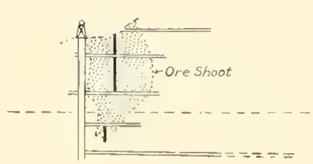
GOLDEN FLEECE



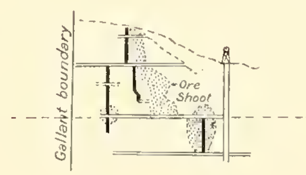
WEALTH OF NATIONS



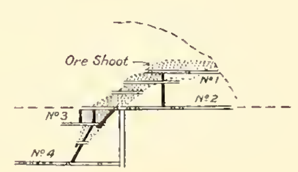
KEEP-IT-DARK



INKERMAN WEST



DRAKE



CUMBERLAND

MINE SECTIONS

Scale

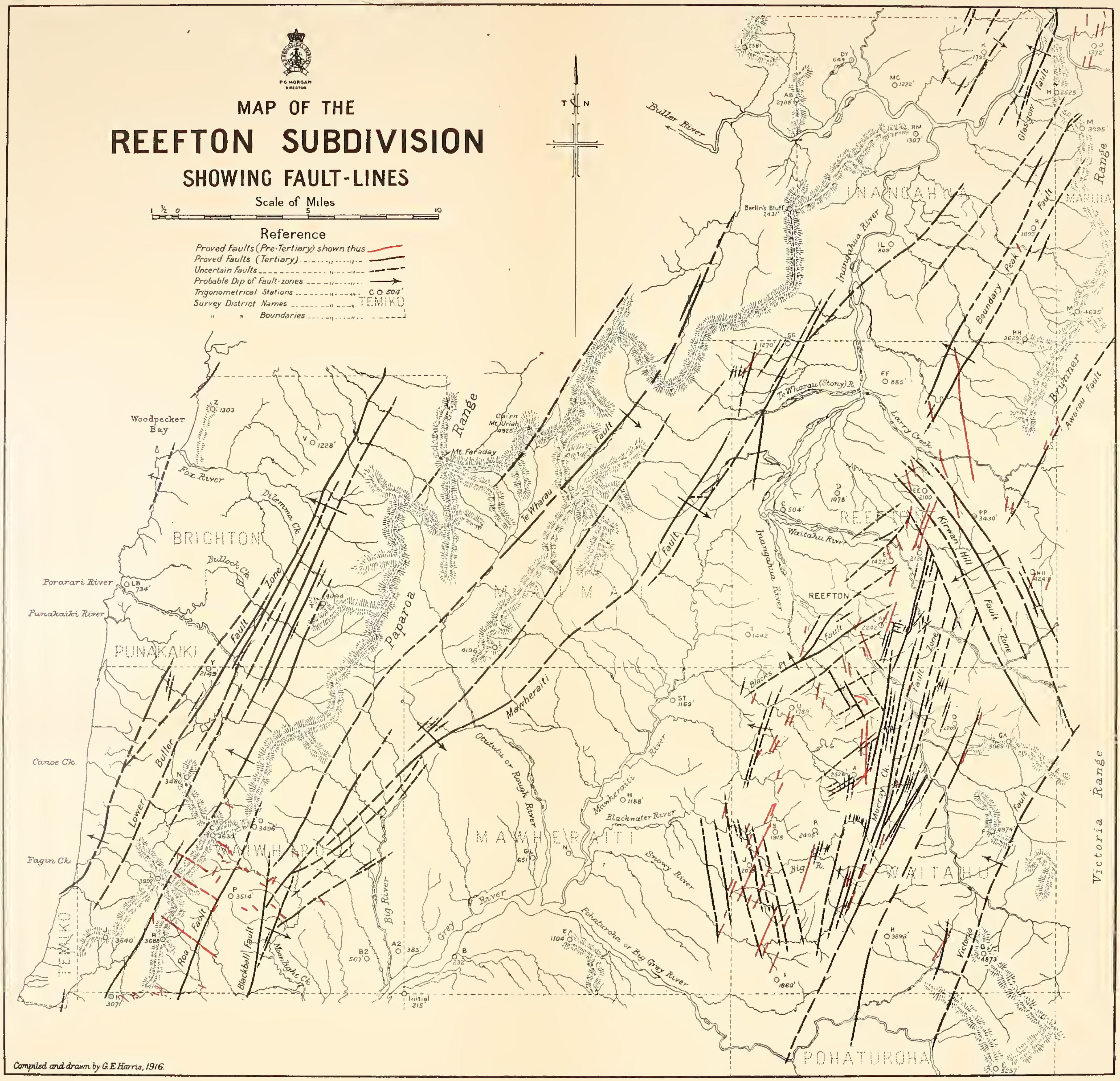
CHAINS 10 5 0 10 20 CHAINS

FEET 1000 500 0 1000 FEET

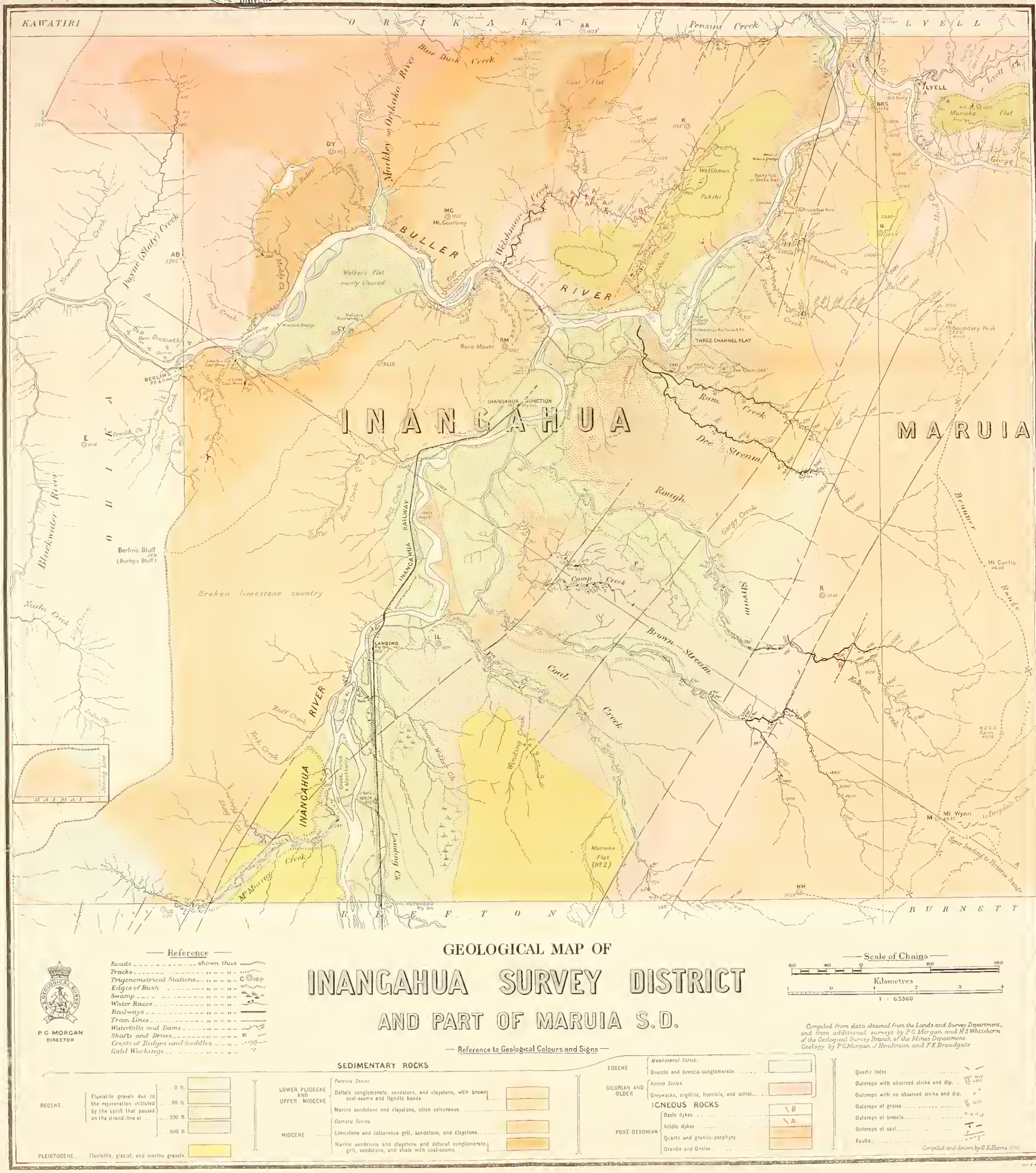
Compiled and drawn by G. E. Harris, 1916

700 10 16 197

Bull. No 18



725.6.16.176


KAWATIRI
O R I K A K A
L Y E L L
INANGAHUA
MARUIA
R E E F T O N
B U R N E T T
BULLER RIVER
INANGAHUA RIVER
INANGAHUA RAILWAY
INANGAHUA JUNCTION
THREE CHANNEL FLAT
LYELL
BERLINS
Broken limestone country
Walker's Flat mostly cleared
Rose Mount
Mt. Courtney
Welshman Pakihi
Berlins Bluff (Burleys Bluff)
Blackwater River
Payne (Slaty) Creek
Blue Duck Creek
Coal Flat
Ram Creek
Dee Stream
Rough Creek
Gorgy Creek
Brown Stream
Camp Creek
Coal Creek
Manuka Flat
Manuka Flat (No 2)
Mt Curtis
Mt Wynn
Brunner Range
Spur leading to Victoria Range
Landing Ck.
Boundary Peak
Three Channel Flat

GEOLOGICAL MAP OF
INANGAHUA SURVEY DISTRICT
AND PART OF MARUIA S.D.

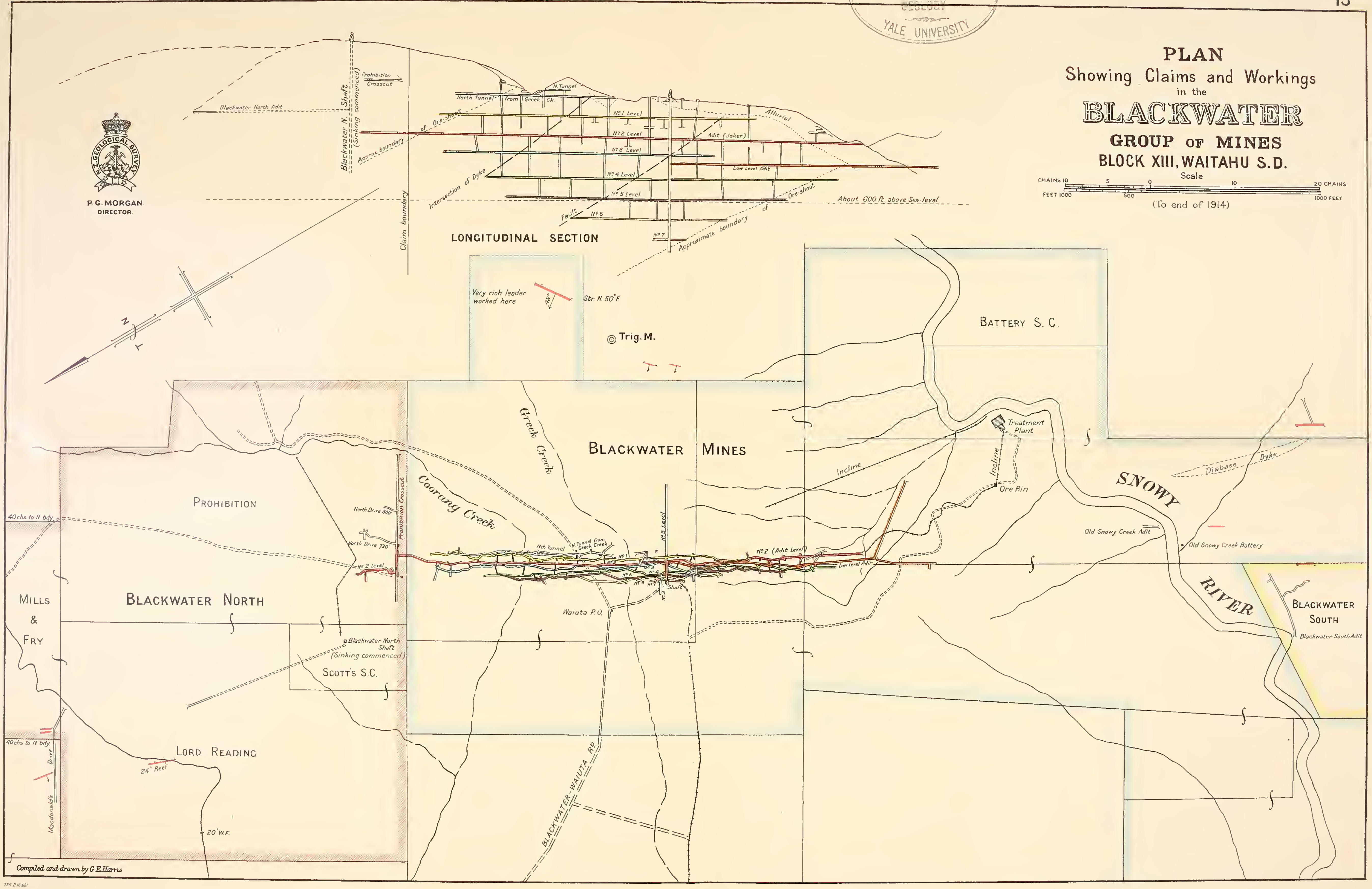
N.Z. GEOLOGICAL SURVEY
P. G. MORGAN
DIRECTOR

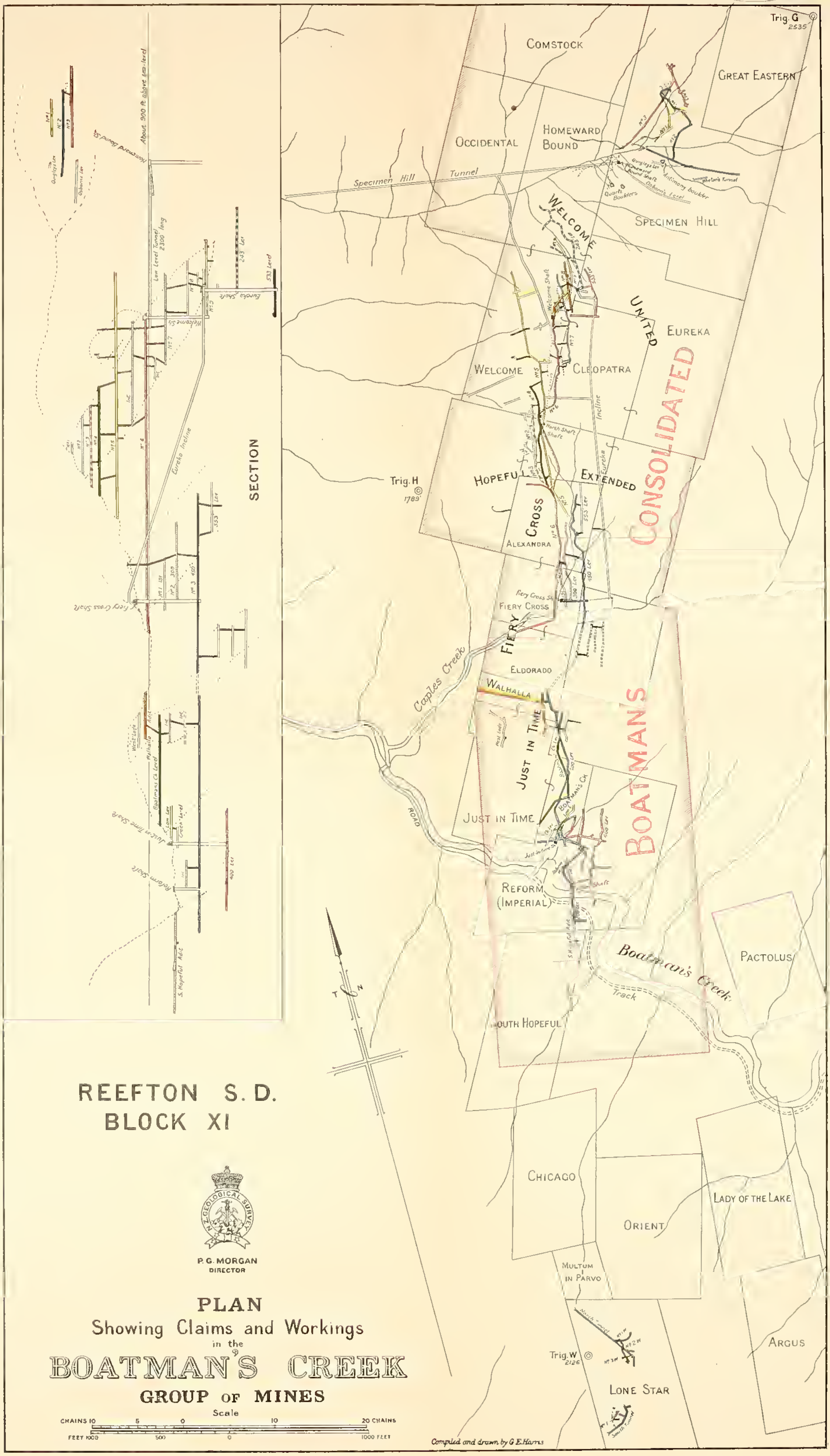
Reference
Roads shown thus
Tracks " "
Trigonometrical Stations " " C ◎1891
Edges of Bush " "
Swamp " "
Water Races " "
Railways " "
Tram Lines " "
Waterfalls and Dams " "
Shafts and Drives " "
Crests of Ridges and Saddles " "
Gold Workings " "

Scale of Chains
80 40 0 80 160
Kilometres
1 0 1 2 3 4
1 : 63360

Compiled from data obtained from the Lands and Survey Department, and from additional surveys by P G Morgan and H S Whitehorn of the Geological Survey Branch of the Mines Department.
Geology by P G Morgan, J Henderson and F K Broadgate

Reference to Geological Colours and Signs
SEDIMENTARY ROCKS
RECENT. Fluviatile gravels due to the rejuvenation initiated by the uplift that paused on the strand-line at 0 ft. / 80 ft. / 200 ft. / 500 ft.
PLEISTOCENE. Fluviatile, glacial, and marine gravels.
LOWER PLIOCENE AND UPPER MIOCENE. Pareora Series. Deltaic conglomerate, sandstone, and claystone, with brown coal-seams and lignite bands. Marine sandstone and claystone, often calcareous.
MIOCENE. Oamaru Series. Limestone and calcareous grit, sandstone, and claystone. Marine sandstone and claystone and littoral conglomerate, grit, sandstone, and shale with coal-seams.
EOCENE. Mawheranui Series. Breccia and breccia-conglomerate.
SILURIAN AND OLDER. Aorere Series. Greywacke, argillite, hornfels, and schist.
IGNEOUS ROCKS
POST-DEVONIAN. Basic dykes. B / Acidic dykes. A / Quartz and granite-porphyry / Granite and Gneiss.
Quartz lodes
Outcrops with observed strike and dip.
Outcrops with no observed strike and dip.
Outcrops of gneiss.
Outcrops of breccia.
Outcrops of coal.
Faults.
Compiled and drawn by G E Harris 1916


PLAN
Showing Claims and Workings in the
BLACKWATER
GROUP OF MINES
BLOCK XIII, WAITAHU S.D.
Scale
CHAINS 10 5 0 10 20 CHAINS
FEET 1000 500 1000 FEET
(To end of 1914)
N.Z. GEOLOGICAL SURVEY
P. G. MORGAN
DIRECTOR
LONGITUDINAL SECTION
Blackwater North Adit
Blackwater N. Shaft (Sinking commenced)
Prohibition Crosscut
N. Tunnel
North Tunnel from Greek Ck.
No 1 Level
No 2 Level
No 3 Level
No 4 Level
No 5 Level
No 6
No 7
Alluvial
Adit (Joker)
Low Level Adit
Approx. boundary of Ore shoot
Intersection of Dyke
Fault
Claim boundary
About 600 ft. above Sea-level
Approximate boundary of Ore shoot
Very rich leader worked here
Str. N. 50° E
Trig. M.
BATTERY S. C.
Treatment Plant
Incline
Ore Bin
BLACKWATER MINES
Greek Creek
Coorang Creek
PROHIBITION
North Drive 500
North Drive 730
No 2 Level
Nth Tunnel
N. Tunnel from Greek Creek
No 2 (Adit Level)
No 3 Level
Shaft
Waiuta P.O.
SNOWY RIVER
Diabase Dyke
Old Snowy Creek Adit
Old Snowy Creek Battery
BLACKWATER SOUTH
Blackwater South Adit
40 chs. to N bdy.
MILLS & FRY
BLACKWATER NORTH
Blackwater North Shaft (Sinking commenced)
SCOTT'S S.C.
LORD READING
24" Reef
20' W.F.
Macdonald's Drive
BLACKWATER-WAIUTA RD.
Compiled and drawn by G.E.Harris



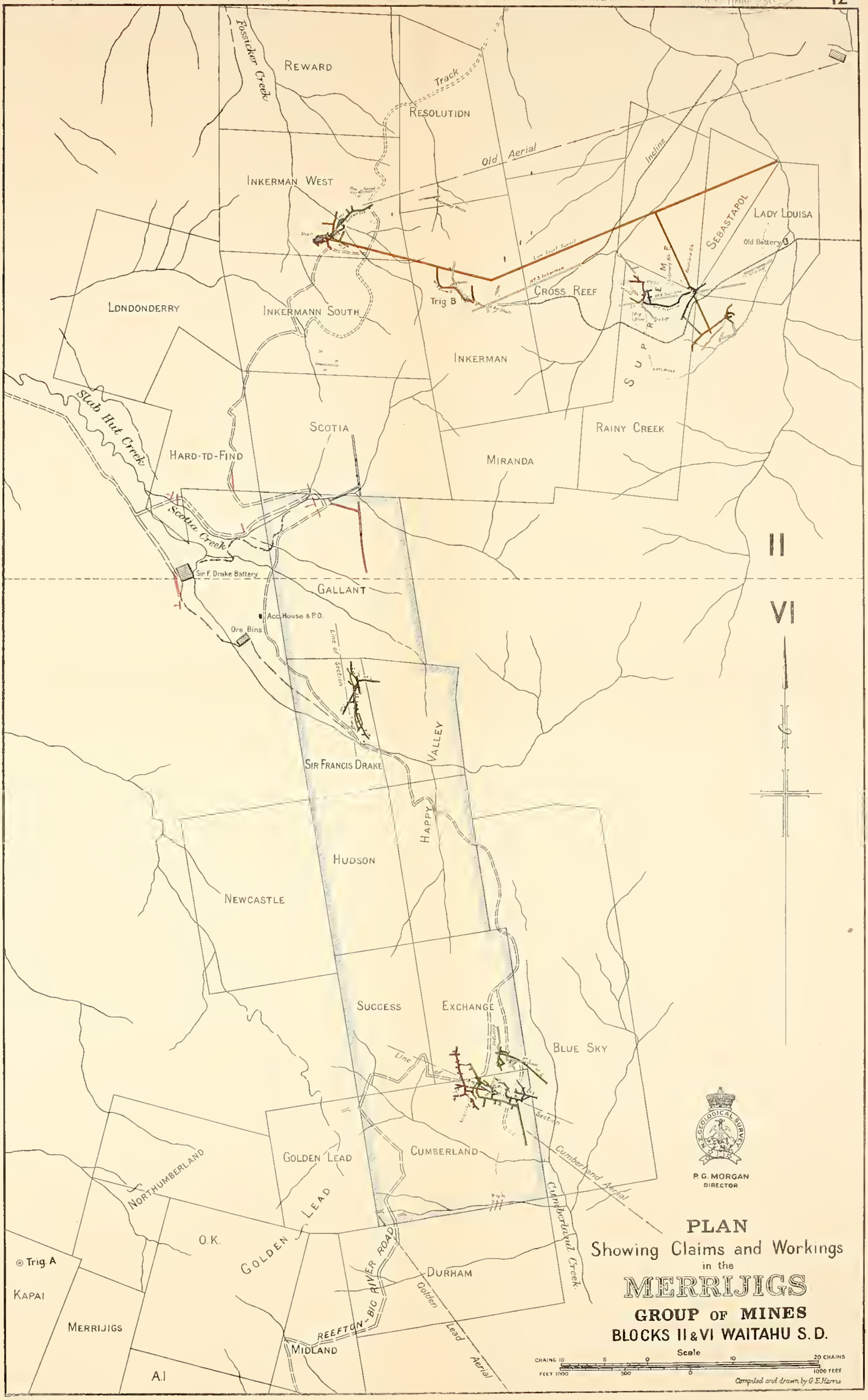
REEFTON S.D.
BLOCK XI

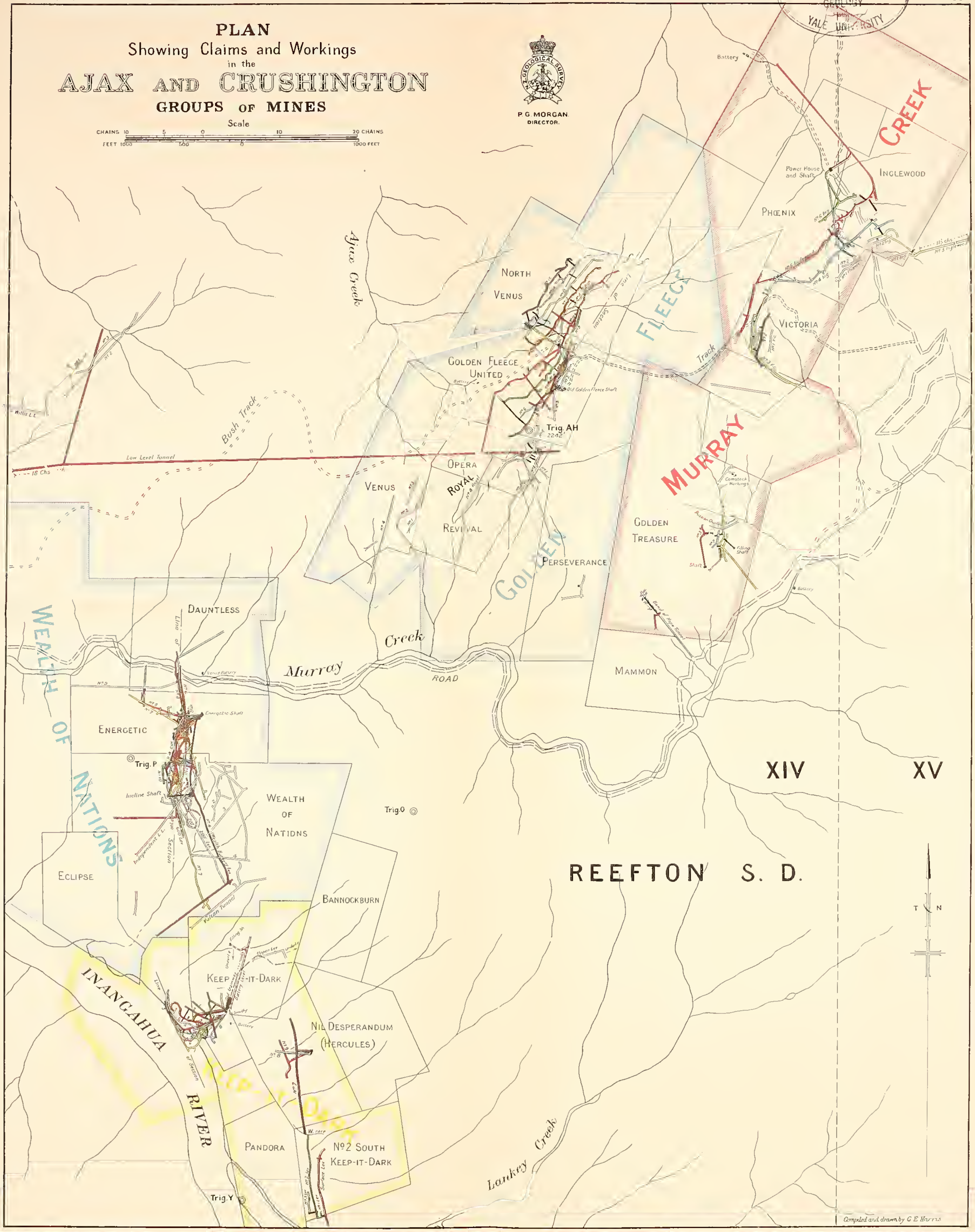
P. G. MORGAN
DIRECTOR

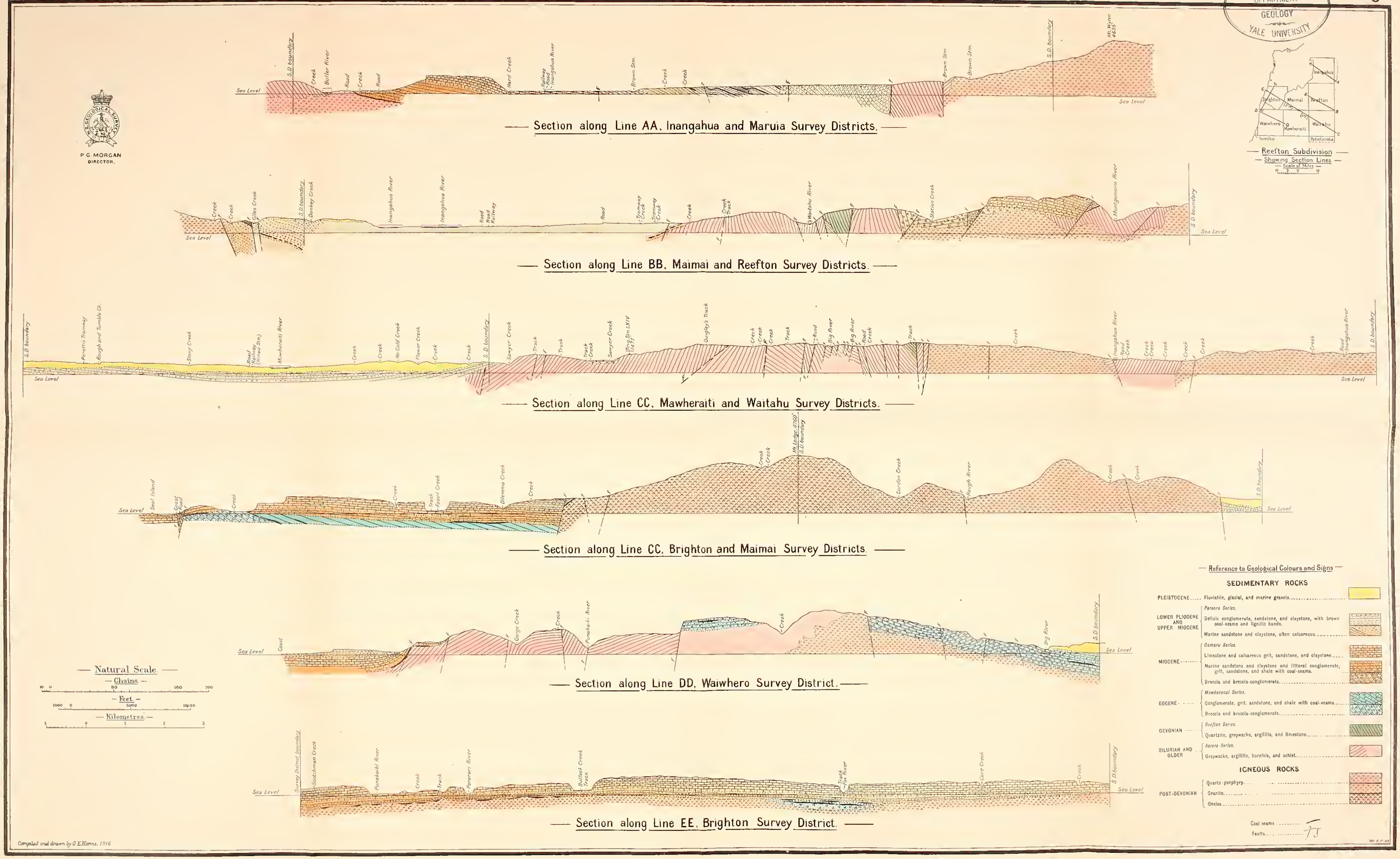
PLAN
Showing Claims and Workings
in the
BOATMAN'S CREEK
GROUP of MINES

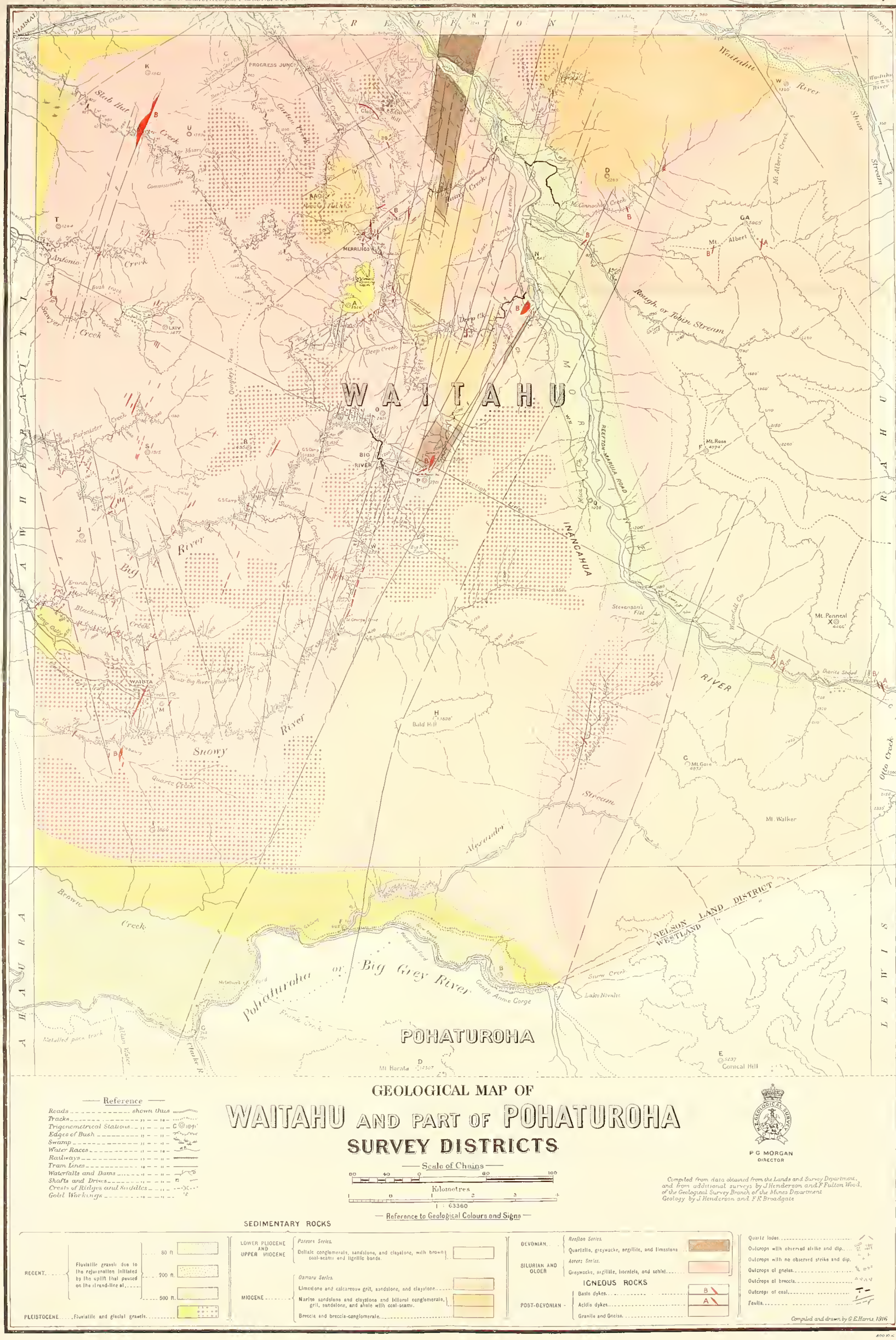
Scale
CHAINS 10 5 0 10 20 CHAINS
FEET 1000 500 0 1000 FEET

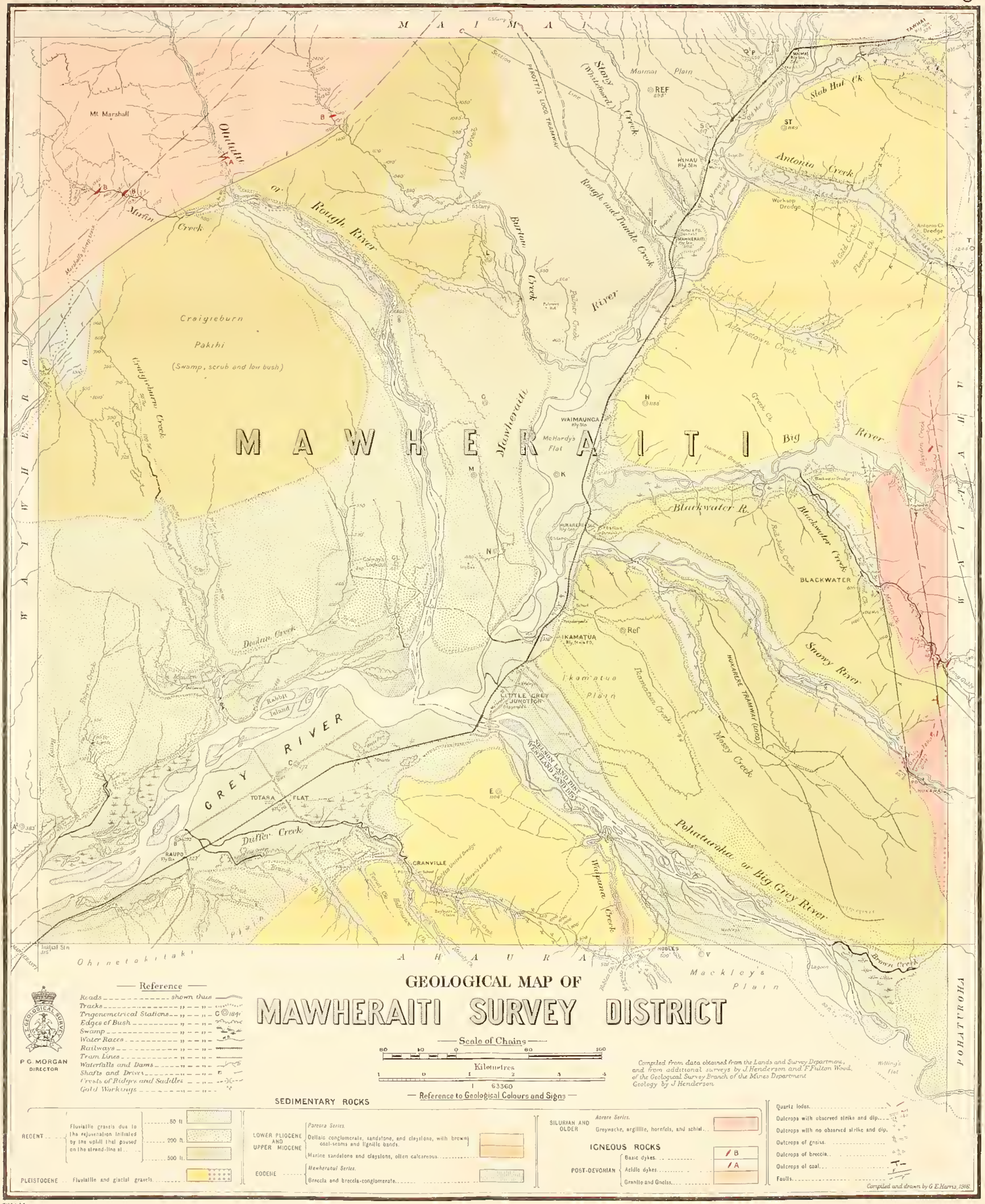
Compiled and drawn by G. E. Harris

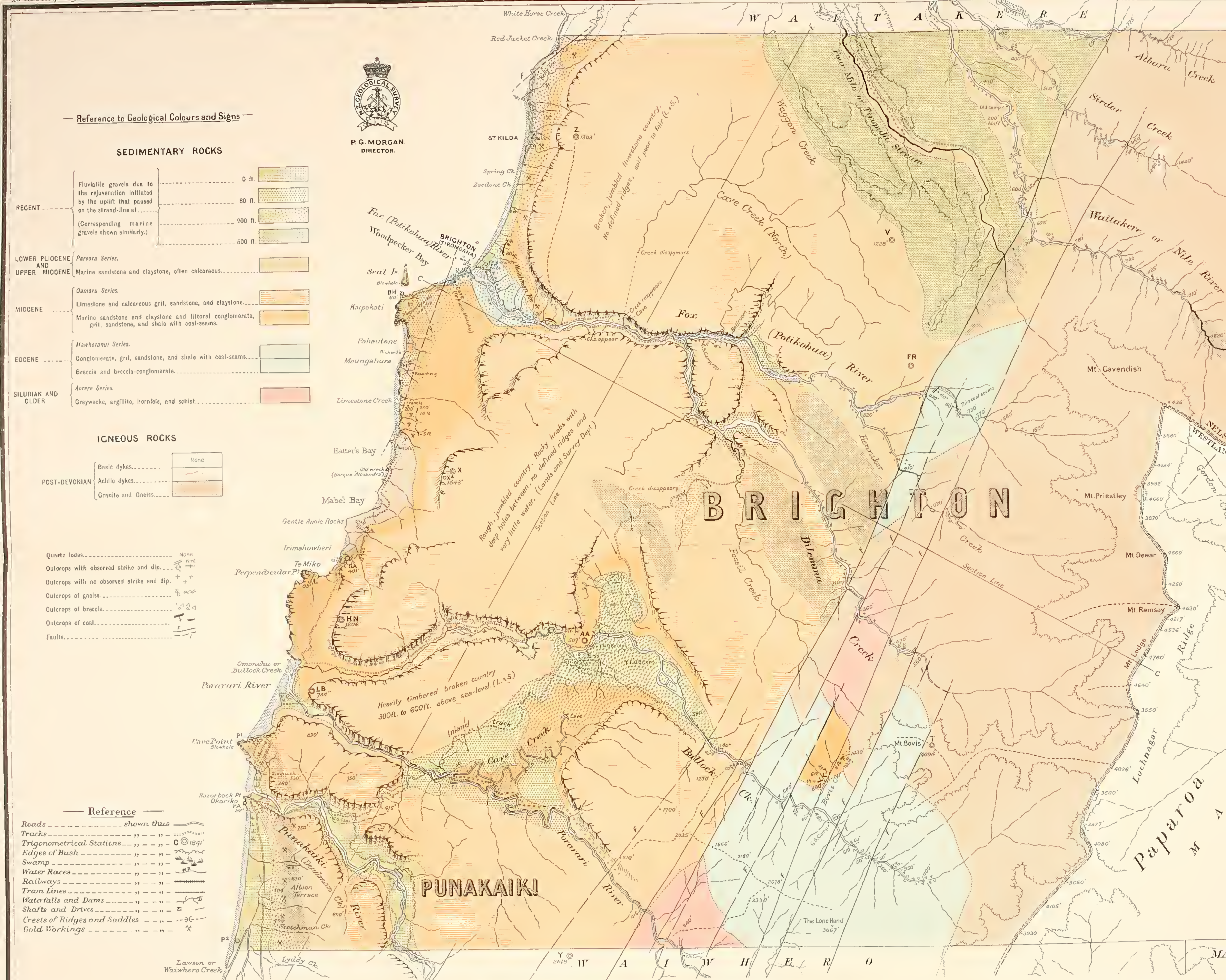

Fossicker Creek
Reward
Track
Resolution
Old Aerial
Incline
Inkerman West
Sebastapol
Lady Louisa
Old Battery
Londonderry
Inkermann South
Trig B
Cross Reef
Supreme
Inkerman
Slab Hut Creek
Scotia
Rainy Creek
Hard-to-Find
Miranda
Scotia Creek
Sir F. Drake Battery
Gallant
II
VI
Acc. House & P.O.
Ore Bins
Line of Section
Sir Francis Drake
Valley
Happy
Hudson
Newcastle
Success
Exchange
Blue Sky
Line of Section
Golden Lead
Cumberland
Cumberland Aerial
Northumberland
Golden Lead
Cumberland Creek
Trig. A
O.K.
Reefton-Big River Road
Durham
Kapai
Golden Lead Aerial
Merrijigs
Midland
A.1
N.Z. Geological Survey
P. G. Morgan
Director
PLAN
Showing Claims and Workings
in the
MERRIJIGS
GROUP OF MINES
BLOCKS II & VI WAITAHU S. D.
Scale
Chains 10 5 0 10 20 Chains
Feet 1000 500 0 1000 Feet
Compiled and drawn by G. E. Harris


PLAN
Showing Claims and Workings
in the
AJAX AND CRUSHINGTON
GROUPS OF MINES
Scale
CHAINS 10 5 0 10 20 CHAINS
FEET 1000 500 0 1000 FEET
N.Z. GEOLOGICAL SURVEY
P. G. MORGAN. DIRECTOR.
Battery
CREEK
INGLEWOOD
Power House and Shaft
PHŒNIX
NORTH VENUS
FLEECE
VICTORIA
Track
Ajax Creek
Line of Section
GOLDEN FLEECE UNITED
Battery
Old Golden Fleece Shaft
Bush Track
Trig. AH 2242'
Low Level Tunnel
18 Chs
Willis L.L.
MURRAY
OPERA
ROYAL
VENUS
REVIVAL
Comstock Workings
GOLDEN TREASURE
GOLDEN
PERSEVERANCE
Filling Shaft
Shaft
Battery
WEALTH OF NATIONS
DAUNTLESS
Creek
Murray
ROAD
MAMMON
Energetic Shaft
ENERGETIC
Trig. P
Incline Shaft
WEALTH OF NATIONS
Trig. O
XIV
XV
Independent L.L.
Section
ECLIPSE
REEFTON S. D.
BANNOCKBURN
Vulcan Tunnel
T N
INANGAHUA
KEEP-IT-DARK
Battery
NIL DESPERANDUM (HERCULES)
RIVER
PANDORA
No2 SOUTH KEEP-IT-DARK
Lankey Creek
Trig. Y
Compiled and drawn by C. E. Harris


N.Z. GEOLOGICAL SURVEY
P. G. MORGAN
DIRECTOR.
Section along Line AA, Inangahua and Maruia Survey Districts.
Section along Line BB, Maimai and Reefton Survey Districts.
Section along Line CC, Mawheraiti and Waitahu Survey Districts.
Section along Line CC, Brighton and Maimai Survey Districts.
Section along Line DD, Waiwhero Survey District.
Section along Line EE, Brighton Survey District.
Reefton Subdivision
Showing Section Lines
Natural Scale
Chains
Feet
Kilometres
Reference to Geological Colours and Signs
SEDIMENTARY ROCKS
PLEISTOCENE — Fluviatile, glacial, and marine gravels.
LOWER PLIOCENE AND UPPER MIOCENE — Pareora Series. Deltaic conglomerate, sandstone, and claystone, with brown coal-seams and lignitic bands. Marine sandstone and claystone, often calcareous.
MIOCENE — Oamaru Series. Limestone and calcareous grit, sandstone, and claystone. Marine sandstone and claystone and littoral conglomerate, grit, sandstone, and shale with coal-seams. Breccia and breccia-conglomerate.
EOCENE — Mawheranui Series. Conglomerate, grit, sandstone, and shale with coal-seams. Breccia and breccia-conglomerate.
DEVONIAN — Reefton Series. Quartzite, greywacke, argillite, and limestone.
SILURIAN AND OLDER — Aorere Series. Greywacke, argillite, hornfels, and schist.
IGNEOUS ROCKS
POST-DEVONIAN — Quartz-porphyry. Granite. Gneiss.
Coal seams
Faults
Compiled and drawn by G. E. Harris, 1916


REEFTON
WAITAHU
POHATUROHA
MAWHERAITI
LEWIS
INANGAHUA
Waitahu River
Slab Hut Creek
Big River
Snowy River
Rough or Tobin Stream
Poharuroha or Big Grey River
NELSON LAND DISTRICT
WESTLAND
Mt. Albert
Mt. Rosa
Mt. Penneal
Mt. Gore
Mt. Walker
Bald Hill
Mt Harata
Conical Hill
Lake Nivale
Stevenson's Flat
REEFTON-MARUIA ROAD
PROGRESS JUNC.
MERRIJIGS
BIG RIVER
WAIUTA
GEOLOGICAL MAP OF
WAITAHU AND PART OF POHATUROHA
SURVEY DISTRICTS
Reference
Roads shown thus
Tracks
Trigonometrical Stations
Edges of Bush
Swamp
Water Races
Railways
Tram Lines
Waterfalls and Dams
Shafts and Drives
Crests of Ridges and Saddles
Gold Workings
Scale of Chains
Kilometres
1 : 63360
P G MORGAN
DIRECTOR
Compiled from data obtained from the Lands and Survey Department, and from additional surveys by J Henderson and F Fulton Wood, of the Geological Survey Branch of the Mines Department
Geology by J Henderson and F K Broadgate
Reference to Geological Colours and Signs
SEDIMENTARY ROCKS
RECENT. Fluviatile gravels due to the rejuvenation initiated by the uplift that paused on the trend-line at 80 ft. 200 ft. 500 ft.
PLEISTOCENE. Fluviatile and glacial gravels
LOWER PLIOCENE AND UPPER MIOCENE Pareora Series. Deltaic conglomerate, sandstone, and claystone, with brown coal-seams and lignite bands.
Oamaru Series.
MIOCENE Limestone and calcareous grit, sandstone, and claystone. Marine sandstone and claystone and littoral conglomerate, grit, sandstone, and shale with coal-seams. Breccia and breccia-conglomerate.
DEVONIAN. Reefton Series. Quartzite, greywacke, argillite, and limestone
SILURIAN AND OLDER Aorere Series. Greywacke, argillite, hornfels, and schist
IGNEOUS ROCKS
POST-DEVONIAN - Basic dykes. Acidic dykes. Granite and Gneiss.
Quartz lodes
Outcrops with observed strike and dip
Outcrops with no observed strike and dip
Outcrops of gneiss
Outcrops of breccia
Outcrops of coal
Faults
Compiled and drawn by G E Harris 1916

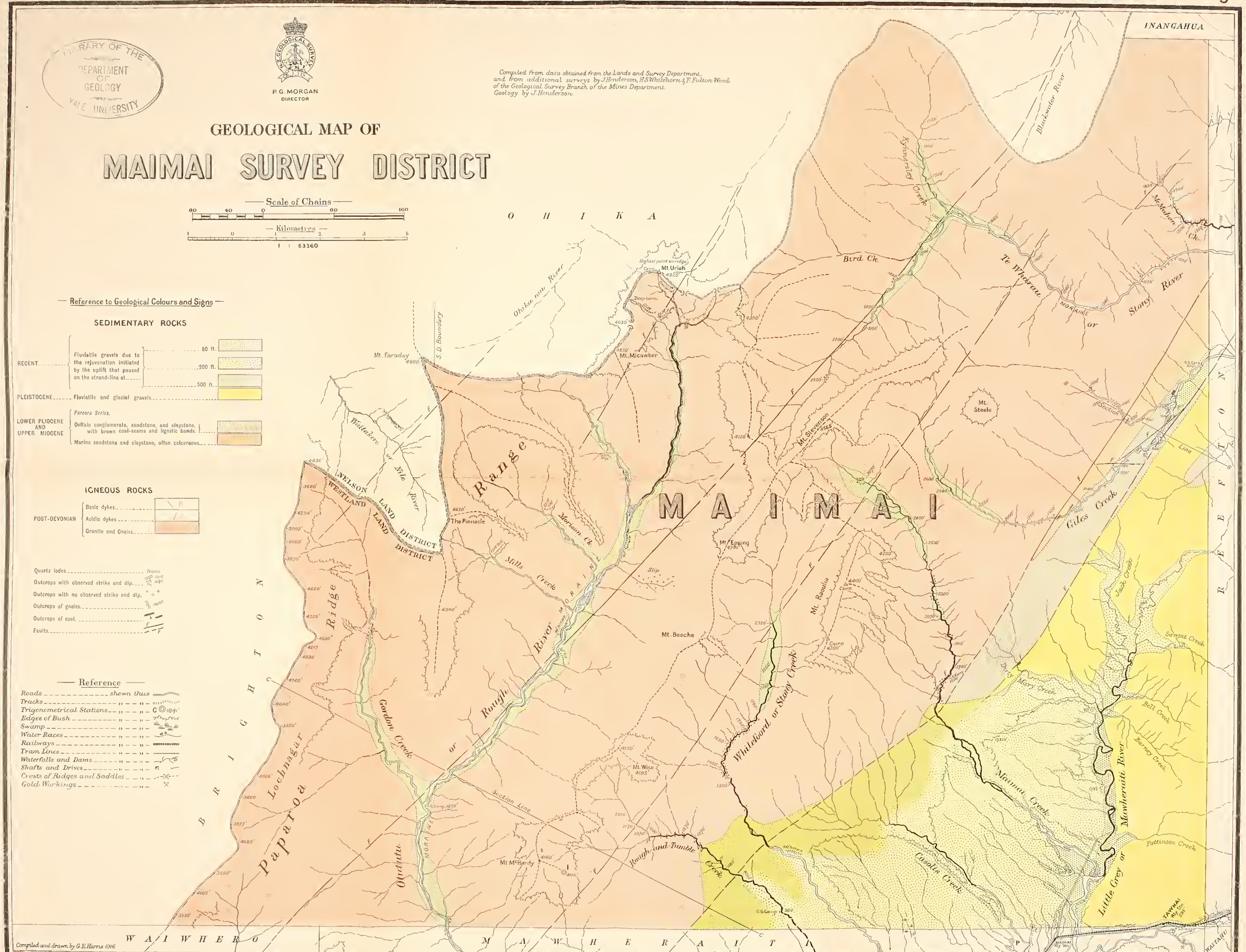

GEOLOGICAL MAP OF
MAWHERAITI SURVEY DISTRICT
MAWHERAITI
MAIMAI
AHAURA
WAIMAUNGA
POHATUROA
Reference
Roads shown thus
Tracks
Trigonometrical Stations
Edges of Bush
Swamp
Water Races
Railways
Tram Lines
Waterfalls and Dams
Shafts and Drives
Crests of Ridges and Saddles
Gold Workings
P. G. MORGAN
DIRECTOR
Scale of Chains
Kilometres
1/63360
Reference to Geological Colours and Signs
Compiled from data obtained from the Lands and Survey Department, and from additional surveys by J. Henderson and F. Fulton Wood, of the Geological Survey Branch of the Mines Department. Geology by J. Henderson.
SEDIMENTARY ROCKS
RECENT
Fluviatile gravels due to the rejuvenation initiated by the uplift that paused on the strand-line at
80 ft.
200 ft.
500 ft.
PLEISTOCENE
Fluviatile and glacial gravels
LOWER PLIOCENE AND UPPER MIOCENE
Pareora Series.
Oolitic conglomerate, sandstone, and claystone, with brown coal-seams and lignitic bands.
Marine sandstone and claystone, often calcareous
EOCENE
Mawheranui Series.
Breccia and breccia-conglomerate
SILURIAN AND OLDER
Aorere Series.
Greywacke, argillite, hornfels, and schist
IGNEOUS ROCKS
POST-DEVONIAN
Basic dykes
Acidic dykes
Granite and Gneiss
Quartz lodes
Outcrops with observed strike and dip
Outcrops with no observed strike and dip
Outcrops of gneiss
Outcrops of breccia
Outcrops of coal
Faults
Compiled and drawn by G. E. Harris, 1916.
Grey River
Big River
Blackwater R.
Snowy River
Pohaturoa or Big Grey River
Rough River
Craigieburn Pakihi (Swamp, scrub and low bush)
Mt Marshall
Ikamatua Plain
Little Grey Junction
Totara Flat
Raupo
Granville
Blackwater
Ikamatua
Hukarere
Mossy Creek
Antonio Creek
Slab Hut Ck.
Adamstown Creek
Duffer Creek
Maimai Plain
Mackley's Plain



GEOLOGICAL MAP OF
BRIGHTON AND PUNAKAIKI SURVEY DISTRICTS

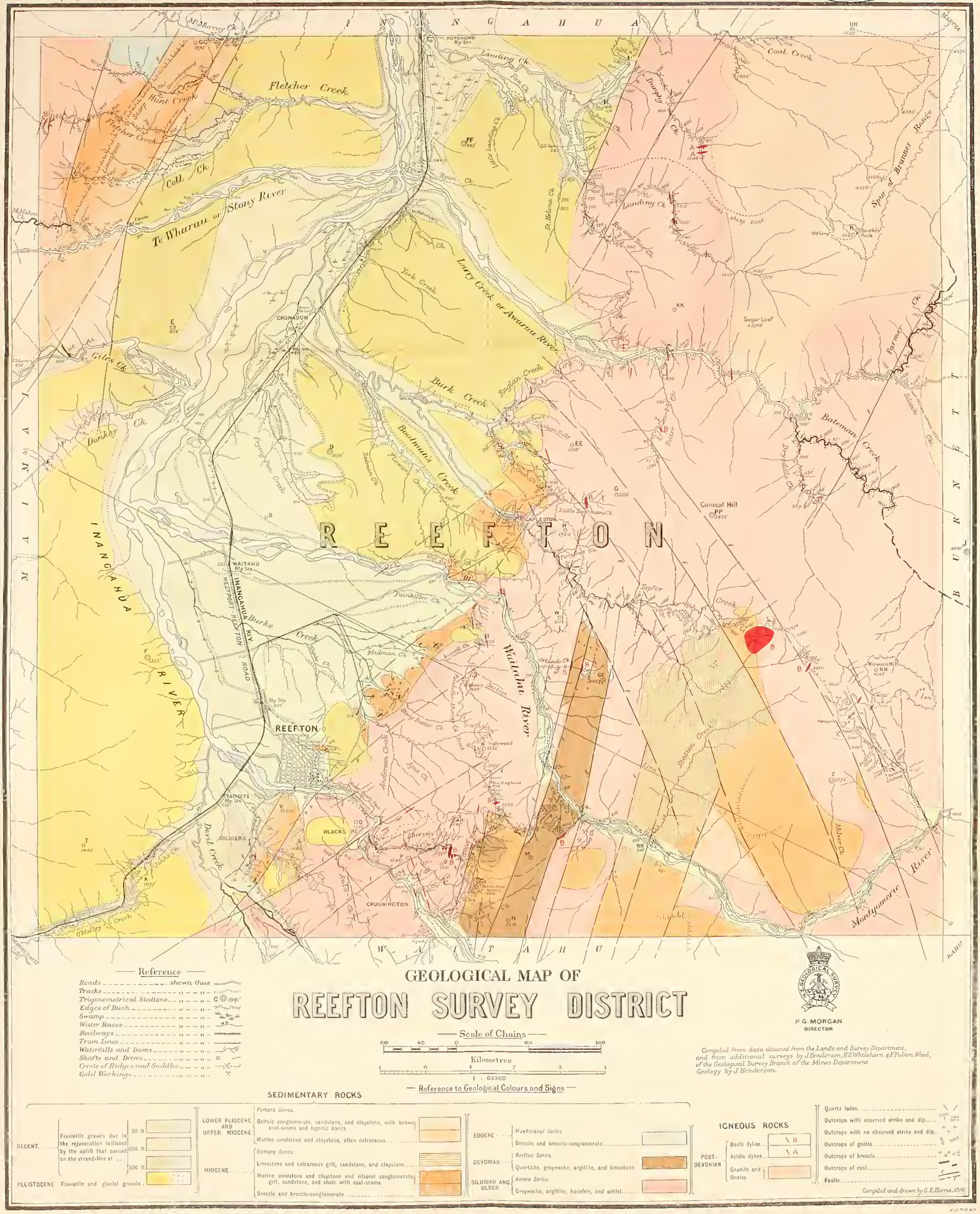
Compiled from data obtained from the Lands and Survey Department, and from additional surveys by J.Henderson, J.A.Bartrum, H.S.Whitehorn, and F.Fulton-Wood of the Geological Survey Branch of the Mines Department. Geology by J.Henderson and J.A.Bartrum.

Scale of Chains 80 40 0 80
Kilometres 1 0 1 2 3
1 : 63360

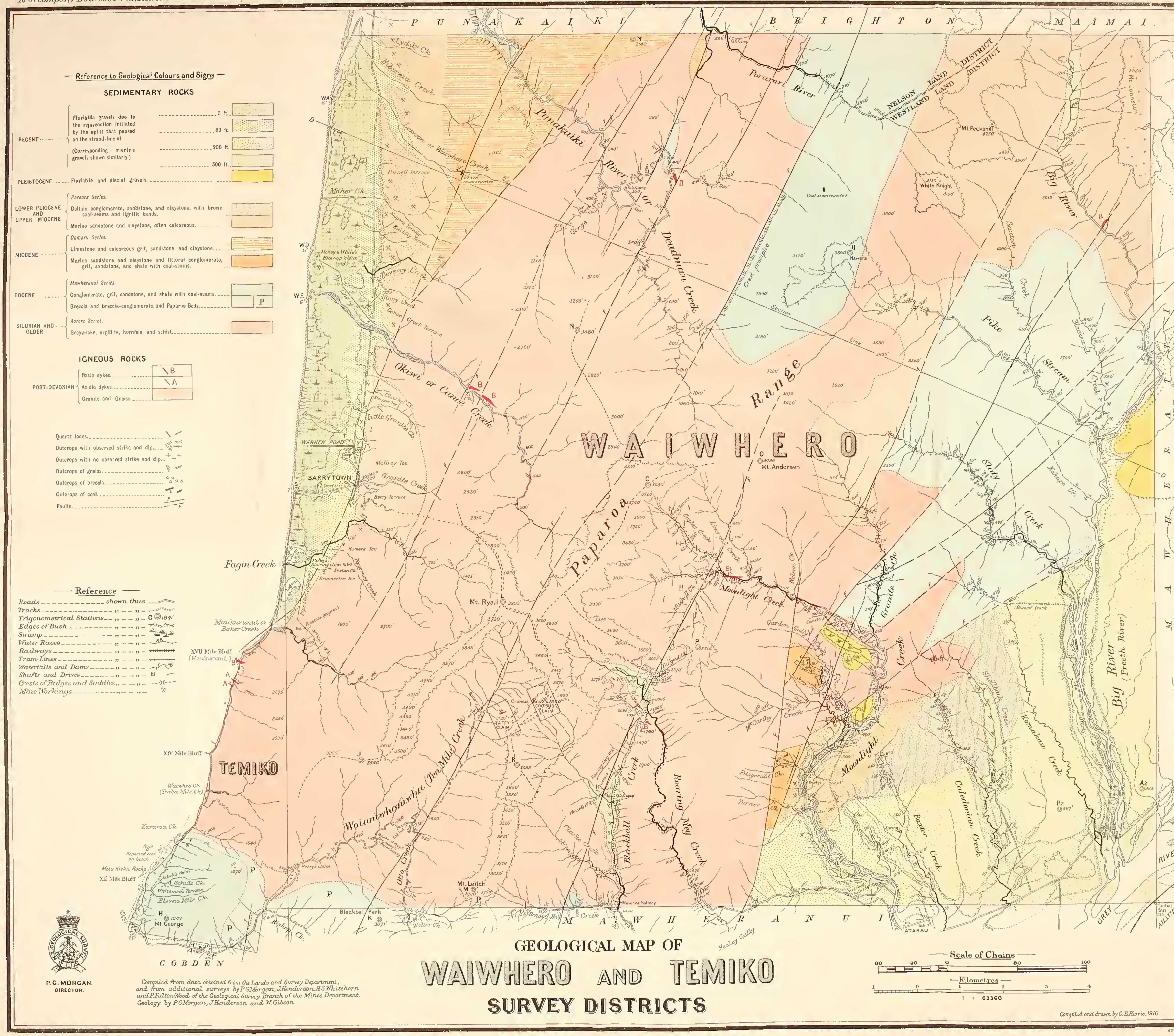


LIBRARY OF THE DEPARTMENT OF GEOLOGY YALE UNIVERSITY
N.Z. GEOLOGICAL SURVEY
P. G. MORGAN
DIRECTOR
Compiled from data obtained from the Lands and Survey Department, and from additional surveys by J. Henderson, H. S. Whitehorn & F. Fulton Wood of the Geological Survey Branch of the Mines Department.
Geology by J. Henderson
GEOLOGICAL MAP OF
MAIMAI SURVEY DISTRICT
Scale of Chains
Kilometres
1 : 63360
Reference to Geological Colours and Signs
SEDIMENTARY ROCKS
RECENT
Fluviatile gravels due to the rejuvenation initiated by the uplift that paused on the strand-line at
80 ft.
200 ft.
500 ft.
PLEISTOCENE
Fluviatile and glacial gravels
LOWER PLIOCENE AND UPPER MIOCENE
Pareora Series.
Oeltaio conglomerate, sandstone, and claystone, with brown coal-seams and lignitic bands.
Marine sandstone and claystone, often calcareous
IGNEOUS ROCKS
POST-DEVONIAN
Basic dykes
Acidic dykes
Granite and Gneiss
Quartz lodes
None
Outcrops with observed strike and dip
Outcrops with no observed strike and dip
Outcrops of gneiss
Outcrops of coal
Faults
Reference
Roads shown thus
Tracks
Trigonometrical Stations
Edges of Bush
Swamp
Water Races
Railways
Tram Lines
Waterfalls and Dams
Shafts and Drives
Crests of Ridges and Saddles
Gold Workings
O H I K A
INANGAHUA
M A I M A I
B R I G H T O N
R E E F T O N
W A I W H E R O
M A W H E R A I T I
Paparoa
Lochnagar Ridge
Range
Rough or Rough River
Whiteford or Stony Creek
Maimai Creek
Little Grey or Mawheraiti River
Moraine or Stony River
Giles Creek
Gordon Creek
Mills Creek
Morrison Ck.
Kynnersley Creek
Blackwater River
Te Wharau
Bird Ck.
McMahon Ck.
Mt. Uriah
Mt. Micawber
Mt. Faraday
Mt. Stevenson
Mt. Steele
Mt. Epping
Mt. Beeche
Mt. Raoulia
Mt. Wise
Mt. McHardy
The Pinnacle
Section Line
Rough and Tumble Creek
Caswells Creek
Jacks Creek
Summit Creek
Bell Creek
Barney Creek
Pattinson Creek
Dirty Mary Creek
NELSON LAND DISTRICT
WESTLAND LAND DISTRICT
S.D. Boundary
Compiled and drawn by G. E. Harris 1916

To accompany Bulletin Nº 18, Reefton Subdivision, Westport and North Westland Divisions, Nelson and Westland Land Districts.



To accompany Bulletin No 18, Reefton Subdivision, Westport and North Westland Divisions, Nelson and Westland Land Districts.



Frontispiece.] PLATE I.—REEFTON, SHOWING THE INANGAHUA RIVER AND PAPAROA RANGE. [*Photo by W. Sherlock.*

NEW ZEALAND.

Department of Mines.

NEW ZEALAND GEOLOGICAL SURVEY.

(P. G. MORGAN, Director.)

BULLETIN No. 18 (NEW SERIES).

THE GEOLOGY AND MINERAL RESOURCES

OF THE

REEFTON SUBDIVISION.

WESTPORT AND NORTH WESTLAND DIVISIONS.

BY

J. HENDERSON.

ISSUED UNDER THE AUTHORITY OF THE HON. W. D. S MACDONALD, MINISTER OF MINES.

WELLINGTON.
BY AUTHORITY: MARCUS F. MARKS, GOVERNMENT PRINTER.

1917

LETTER OF TRANSMITTAL.

GEOLOGICAL SURVEY OFFICE,
Wellington, 12th December, 1916.

SIR,—

I have the honour to submit herewith Bulletin No. 18 (New Series) of the Geological Survey Branch of the Mines Department, written by Dr. J. Henderson, Mining Geologist. It comprises 225 pages of letterpress, together with a large number of maps, plans, and plates.

This Bulletin deals with the general and economic geology of the Reefton Subdivision, which has an area of 1,046 square miles, and is thus the largest district hitherto included in any detailed geological report written in New Zealand. The subdivision contains important mineral resources in the shape of gold—alluvial and vein—and of coal. Although the alluvial gold is apparently nearly exhausted, the gold-quartz veins are expected to give profitable yields for many years to come, and the coal-bearing areas are hardly touched.

A continuous block of country on the west coast of the South Island extending from the Big Wanganui River in South Westland to the neighbourhood of Karamea in West Nelson, and having an area of approximately 3,540 square miles, has now been geologically surveyed in detail. The results obtained are embodied in five other bulletins besides the present—namely, those dealing with the Hokitika, Mikonui, Mount Radiant, Greymouth, and Buller-Mohikinui subdivisions. There still remains, however, a large area of mountainous country in north-west Nelson of which a geological survey at an early date is desirable.

I have the honour to be,
Sir,
Your obedient servant,

P. G. MORGAN,
Director, N.Z. Geological Survey.

The Hon. W. D. S. MacDonald,
Minister of Mines, Wellington.

CONTENTS.

Chapter VI.—Economic Geology.

TABLES.

PLATES.

MAPS AND PLANS.

ADDENDA.

Page 93. For *Lapparia corrugata* Hutt. substitute *Cymbiola corrugata* (Hutt.).
Panope, according to Mr. Suter, has priority over *Panopea*.
Pecten huttoni (Park) occurs on coast south of Seal Island, in calcareous sandstone.

Page 94. The coral *Balanophyllia alta* T.-Woods occurs at Inangahua Junction (Christie's = Loc. No 50).

ERRATA.

Page 112. On Plan of No. 7 Level, Wealth of Nations Mine, "Scale of Chains" should be "Scale of Feet"

In Portfolio. Plan No. 10, "Boatman's Group of Mines," should be "Caplcston Group of Mines."

Facing page 171. On Plan of Big River Group of Mines, Survey Block Nos. II, III, VI, VII, should be respectively VI, VII, X, XI.

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By Authority: John Mackay, Government Printer.

MAP OF
WESTPORT DIVISION
AND PART OF NORTH WESTLAND DIVISION
(NELSON AND WESTLAND LAND DISTRICTS)
SHOWING SURVEY DISTRICTS

Districts dealt with in Bulletin No. 18 coloured thus
" " " previous bulletins " "

ENGLISH MILES
10 0 10 20 30

GEH.

BULLETIN No. 18 (NEW SERIES).

THE GEOLOGY AND MINERAL RESOURCES

OF THE

REEFTON SUBDIVISION.

WESTPORT AND NORTH WESTLAND DIVISIONS.

CHAPTER I.

GENERAL INFORMATION.

INTRODUCTION.

The area described in the present bulletin includes the survey districts of Inangahua, Brighton, Punakaiki, Maimai, Reefton, Temiko, Waiwhero, Mawheraiti, Waitahu, and small portions of Maruia and Pohaturoa survey districts, in all an area of about 1,046 square miles. It may be conveniently termed the Reefton Subdivision from the fact that Reefton, the largest town, is the centre not only of an important industrial district, but also of an interesting geological unit. The districts described in Bulletins Nos. 13 and 17 adjoin the Reefton Subdivision on the south and north respectively, and in many respects have a similar geological structure. Taken together, the three subdivisions form a large part of the region on the west coast of the South Island of New Zealand popularly known as "the West Coast." Save for the alpine meadows and a few pakihis on the lowlands, dense forest until a comparatively short time ago covered the area under discussion, and even now only a small portion of it has been cleared and brought under cultivation.

The mineral wealth of the area described is great, and at Reefton quartz-mining is in a flourishing state. The winning of coal and of alluvial gold is not of great importance; but while the exploitation of the former is likely in the near future to attain large proportions, the production of the latter is likely still further to decrease.

In the valley of the Mawheraiti several sawmilling companies are actively engaged in cutting timber for export, but in the Inangahua basin most of the sawn timber is used by the mines, which also consume large quantities of rough lumber.

Agricultural pursuits have never been extensively followed, owing in part to the unfavourable climate, and in part to the counter-attractions offered by mining. Within the last decade attention has been directed to the dairying industry, with satisfactory results to those interested.

FIELD-WORK AND ACKNOWLEDGMENTS

The field-work upon which this bulletin is based commenced in October, 1912, and was concluded towards the end of May, 1914. During the whole time the writer was in the field he was assisted in the topographical work by Mr. F. Fulton-Wood, while Mr. H. S. Whitehorn similarly assisted in the 1913–14 season. Originally it had been intended to include the Inangahua Survey District in the Buller - Mokihinui Subdivision, and to this end a portion of this area was geologically examined by Mr. P. G. Morgan. To the same geologist is due the mapping of the boundary of the coal-measures in the southern portion of the Waiwhero and Temiko survey districts, a work undertaken in connection with the Greymouth Subdivision. In the summer of 1913 Mr. J. A. Bartrum, M.Sc., explored the headwaters of the Waitakere and Four-mile streams, in the Brighton Survey District. During the summer of 1914 the writer was assisted in geological work by Mr. F. K. Broadgate, M.Sc., and for a month towards the end of the season by Mr. W. Gibson, B.E. For the interpretation of the facts collected by these gentlemen, however, the writer is alone responsible. All analyses quoted in this bulletin, unless it be otherwise expressly stated, are the work of Dr. J. S. Maclaurin, Dominion Analyst, and his staff.

During the progress of the field-work the writer has become indebted to many persons for courtesies which have facilitated his task. It is impossible to mention here by name all those to whom the thanks of the Geological Survey are due, but especial indebtedness must be acknowledged to Messrs. A. Winter Evans and R. Burley, of the Consolidated Goldfields, and to Messrs. T. Hubert Lee and W. Hindmarsh, legal managers of the Big River and Keep-it-Dark companies respectively, for the use of many plans and records. The writer takes pleasure in here recording his appreciation of the facilities afforded him in his mine-examination by all the mine-managers of the Reefton district. Mr. George G. Wise, than whom no one knows more of the early days of the Reefton goldfield, kindly read the writer's notes on the history of the various mining properties, and whatever of merit these contain is largely due to his criticism and help.

CLIMATE.

The climate of the Reefton Subdivision is similar to that obtaining in the neighbouring districts described in Bulletins Nos. 1, 6, 13, and 17. These areas, however, differ from that described in this report in that they lie almost entirely open to the ocean, while the larger portion of the Reefton Subdivision is separated from it by the Paparoa Range, which exercises a sheltering effect, lessened, however, by its limited length and by a decrease in elevation both to the north and south. Thus the north-westerly rain-bearing winds cross the depression to the north of the range without losing a large proportion of their moisture-content, and then, deflected by the long unbroken barrier of the eastern mountains, sweep without interruption the whole length of the Inangahua-Grey valley. Nevertheless, it is certain that the Paparoas do modify the climate and rainfall of this valley to some extent, especially in the southern portion of the subdivision. The following table, kindly supplied by the Dominion Meteorologist, shows the rainfall of most of the stations on the west coast of the South Island. Except Denniston, Reefton, and Otira, all are coastal stations, and show very instructively the progressive increase in the rainfall from the north southward. Denniston, though barely four miles from

[*Photo by W. Sherlock.*

Plate II.—View of Old Winding-wheel of the Wealth of Nations Mine, showing Icicles, etc.

Face p. 3.]

the coast, is situated at a height of 1,900 ft. above sea-level, whilst Otira lies in a valley in the heart of the Alps; and their records indicate the heavier and more frequent rain induced by the mountains. The position of Reefton, on the other hand, would suggest an annual rainfall of 90 in., and the actual less amount recorded is probably due to the sheltering influence of the Paparoa Range.

Mean Monthly Rainfall, in Inches.

——	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Number of Years.
Westport ..	7·01	4·42	5·99	6·47	6·61	7·47	6·74	6·09	7·03	6·67	6·97	6·89	78·36	23
Greymouth ..	9·39	6·00	9·11	8·54	8·18	8·68	7·75	7·26	7·88	10·07	9·05	8·99	100·90	25
Hokitika	..	..	..	..	..	..	..	..	..	..	..	..	116·23	34
Okuru	12·76	9·58	15·75	13·78	12·17	11·62	10·48	10·79	12·54	15·55	11·52	11·62	148·16	10
Denniston ..	7·07	4·24	6·06	7·29	8·22	8·01	6·84	7·00	7·05	9·60	9·88	8·72	89·98	12
Reefton	6·28	3·39	5·64	6·82	6·63	8·51	6·17	6·97	8·39	7·27	7·99	6·60	80·66	12
Otira	17·15	9·59	15·44	19·71	14·86	15·78	11·88	13·03	20·21	22·40	17·84	17·81	195·70	10

The prevailing wind of the district is undoubtedly from the south-west; and this wind, although usually accompanied by fine weather, sometimes brings showers, especially in winter and spring. Easterly winds are always dry, and the heavy rainfall is caused by great cyclones from the Tasman Sea impinging on the mountains. Rain usually sets in with a north-north-east wind, which rapidly veers to the north and north-west. The weather begins to clear when the wind reaches the west point, and then changes to showery and fine with a south-west wind.

Proximity to the sea renders the temperature of the coastal districts more equable than that of the Grey-Inangahua valley. On the coast snow rarely falls, and never lies; while frosts are of short duration, confined to the winter months, and of a mild nature. In the Grey-Inangahua valley, on the other hand, frosts have a wider range in time, and are much more severe, especially when the mountains are snow-covered, as much as 16° of frost having been recorded at Reefton. Nearly every winter several snowfalls occur in the valley lowlands, and in shady places the snow may lie for many days.

Another frequent and most unwelcome visitant during the winter is a cold fog, which envelops the valley soon after sunrise, and does not disperse till midday or later. Reefton, by reason of its position in the bottom of a bowl of hills open only to the north, is almost windless, and is peculiarly liable to this icy mist. No relief from the fog is obtained until either the vapour is removed by cold or the atmosphere cleared by rain. Thus on winter nights the fog condenses as hoar-frost, but re-forms soon after sunrise; and the day following rain is exempt from fog, which, however, generally soon reappears. When for any reason radiation from the earth is insufficient to produce a freezing temperature the fog persists day and night, and may continue for weeks until scattered by some unusual wind-current or dissolved by rain. The Grey-Inangahua valley lies between two great parallel ranges with its extremities barricaded by hills, the only drainage outlets being the gorges of the Buller and the Grey. Thus in fine still weather these form channels by which the heavy air of the valley, cooled in the night by earth-radiation, escapes to the lower level of the sea. In consequence, during the morning hours there draws through the gorges a steady wind which in winter is so keen and cutting as to be jocularly known as "the barber."

In summer, though the extremes of temperature are not excessive, the high atmospheric humidity makes the heat oppressive at times. The highest temperatures are experienced in the Grey-Inangahua valley, where the thermometer occasionally registers 90° F. in the shade.

FLORA.

The writer feels himself incompetent to attempt a full description of the native flora of the subdivision, which is similar to that of the areas described in Bulletins Nos. 1, 6, 13, and 17, and will confine himself to enumerating such facts of plant-distribution as forced themselves under his notice. In the coastal district, which includes the region between the mountains and the sea, the vegetation is very dense, and several plants occur there which are rare or absent from the Grey-Inangahua valley. Thus the nikau (*Rhopalostylis sapida*), kiekie (*Freycinetia Banksii*), and hinau (*Elæocarpus dentatus*), while abundant on the coast, are entirely wanting from the Grey-Inangahua valley. The mamaku (*Cyathea medullaris*) and tree-nettle (*Urtica ferox*) penetrate inland as far as the Buller-Orikaka junction, while the toro (*Myrsine salicina*), and rangiora (*Brachyglottis rangiora*) flourish on the limestone soil as far from the coast as The Landing and Lyell. The ti-ngahere (*Cordyline Banksii*) has a similar range, but a few plants were also noticed in the Inangahua valley above Crushington. The supplejack (*Rhipogonum scandens*) and kidney-fern are rare and local in the Grey-Inangahua valley, although common near the coast.

The forest-trees of the lowlands are similar in both the coastal and inland regions, but the Inangahua valley as a whole is dominoted by the beeches, while the pines are pre-eminent in the Grey and on the coast. Much of the higher terrace land of the lowlands is swampy and bare, or, at the most, scantily forested. On approaching such an area from a river it will be noted that the mixed forest of the flood-plain and lower terraces becomes more open, and that the beeches increase in number. The breech-zone gives place to one of stunted rimu, which in turn merges into the kawhaka-silver-pine forest of the swamps. Finally the silver-pines grow smaller, and are replaced by clumps of stunted manuka, the open moor being covered with moss and low fern, in spring and early summer gay with the blue flowers of *Thelymitra* and the pink rosettes of *Drosera*.

The fragrant *Carmichælia* is present on the edge of every mountain-stream, and *Rubus parvus* often carpets sunny boulder mounds in the upper reaches, where also the handsome toi (*Cordyline indivisa*) has its home. The mountains have their zones of plant-assemblages. Thus, rising on the mountain-flanks the mixed lowland forest with its dense undergrowth becomes more open, and beeches replace the pines. The large-leaved totara (the brittle *Podocarpus Hallii*, not the much more valuable *Podocarpus totara* of the lowlands) is common from 1,000 ft. to 1,400 ft., between which limits the South Island rata (*Meterosideros lucida*) also flourishes, and at higher levels replaces the totara. In turn these give place to the mountain-beech (*Fagus cliffortioides*) and the kawhaka; whilst at last just below the fell-fields or alpine meadowland the mountain-pine (*Dacrydium intermedium*) and neinei (*Dracophyllum Traversii*) appear.

The alpine meadows usually commence at 3,500 ft. above sea-level on the Paparoas and at 4,000 ft. on Victoria Range. The position of the forest-line appears to be determined by the amount of winter snow, for its height on the Victoria-Brunner-Lyell Range decreases to the north as the highlands project beyond the protection from the moist west winds afforded by the Paparoas. Much has been written concerning the flora of the fell-fields of New Zealand. Those in the Reefton Subdivision do not appear to differ in any degree from similar meadows in Westland. Nowhere either on the Paparoa or the Victoria Range was *Ranunculus Lyallii* observed, and the vegetable sheep (*Raoulia* sp.) is apparently not widespread, having been noted only on the western mountains, on mounts Raoulia, Epping, and Uriah.

FAUNA.

As in other parts of New Zealand, the indigenous fauna is becoming every year less conspicuous. The kiwi (*Apteryx australis* and perhaps *A. Oweni*) is still to be found in the mountain-valleys, and was observed in the summer above the timber-line on the Paparoa Range. It is now decidedly more common than the weka, which only a few years ago was very plentiful. The cry of this latter bird was heard once in the Grey valley near the Waipuna, and a few were seen near the mouth of the Orikaka. The boom of the kakapo was heard more than once in the fastnesses of the mountains, and their tracks were noted above the timber-line of the western range. Crows and robins were occasionally seen, but are very scarce; while pigeons, kakas, and pukekos, though often seen, cannot be said to be plentiful. The grey warbler, bell-bird, tui, rock-wren, fantail, and tomtit are quite common, even in settled localities. A few paradise ducks were observed on the Buller; the grey duck is fairly common; and every mountain-stream has its pair or more of beautiful blue ducks (whio). Shags of more than one species are very numerous, and have regular nesting-places in Shag Creek and the Te Wharau and Waitahu rivers, in the last-named stream beyond the limits of the subdivision. Kokopo are numerous in all the less-frequented streams, and eels are plentiful in all, while the lamprey was occasionally observed. The fact that seals were once abundant on the coast is commemorated in the name Seal Island (Brighton), and it is reported that this mammal still occasionally visits the locality.

Of introduced animals the largest is the red deer, of which a small but increasing herd live in the valley of the upper Inangahua. Fallow deer are common enough on the pakihis near Craigieburn (west side of Grey River) and the near-by valley of the Big or Freeth River, and one stag was observed in Fletcher Creek, in the Inangahua valley. The domestic goat has taken to the bush, and is abundant in the forest from Boatman's northward to Lyell, and again in the coastal regions, especially in the valley of the Punakaiki. Other feral animals are the cattle that live on the mountains at the head of Moonlight Creek and in the upper Waitahu, the pigs to be found in the lowlands northward of Larry's Creek, and the occasional forlorn sheep observed on the Brunner and Paparoa ranges; these latter having been missed in the mustering at the time, a few years ago, when sheep were depastured on the mountain-meadows. The Australian opossum is doing well in the bush country between the Otututu and Freeth rivers, and the fur of the New-Zealand-born animals is said to be superior to that of the Australian native. Hares are often seen on the river-beds and open country, but rabbits do not thrive. Stoats are quite plentiful, and seem to be replacing the weasel, which, though common a few years ago, is now rarely seen. Of introduced birds the Californian quail is locally abundant, while the birds which constitute the small-bird nuisance are increasingly numerous. Trout have been successfully introduced into the rivers, and many fine fish were seen. In the Inangahua, from Crushington to the Waitahu junction, the discharge of cyanide-residues into the stream renders it intolerable to animal-life, and a similar condition prevails in portions of the Big and Snowy rivers.

EARLY HISTORY.

In 1642 Abel Jansen Tasman sighted the west coast of the South Island, and, sailing northward, roughly mapped the coast, a work continued by Cook in 1770. To the latter navigator is due the name of Cape Foulwind; but after his visit no explorer of note has any record of observation until Dumont D'Urville sighted the Paparoa Range in the neighbourhood of Barrytown, and sailed northward along the coast.* Next to visit this region were sealers, and about 1836 a post was established near Cape Foulwind under one Thom. In 1845 the New Zealand Company sent out two surveyors, Thomas Brunner and Charles Heaphy, to explore the West Coast. These travelled along the coast-line from West Wanganui to as far south as the Arahura

* January, 1827.

River, and returned by the same route. During 1846–48 the intrepid Brunner, this time without a white companion, descended the Buller from its source to the sea, and traversed the coast-line as far south as Okarito. His original intention had been to cross into Otago, but he returned to the Grey, pushed up that river (discovering coal at Brunnerton) and the Mawheraiti, descended the Inangahua, which he called the "Inangahua" or "Oweka," and, after suffering incredible hardships, returned to Nelson by his former route along the Buller.

In 1853 Sir George Grey began negotiations for the purchase from the Natives of the coastal lands between Kahurangi Point and Milford Sound. This purchase was eventually completed in 1860 by Mr. James Mackay, who in the meantime had explored much of western Nelson. In 1859 Mr. John Rochfort commenced a survey of the chief streams for the Nelson Provincial Government, and in the course of this work traversed the lower Grey, Mawheraiti, Inangahua, and Buller rivers. It was the members of his party, which consisted of Maoris, who first discovered payable gold on the West Coast, at a spot on the north bank of the Buller near the boundary of the subdivision, later known as "Old Diggings." Earlier in the same year (1859) Dr. Haast, who had been commissioned by the provincial authorities to report on the suitability of west Nelson for settlement, and on its geology and mineral resources, left Nelson, reached the coast by way of the Maruia and Grey valleys, and returned via the coast through Collingwood. The discovery by Rochfort's party attracted gold-seekers, and in 1859 a party from Canterbury came to the Buller by sea, but were forced to return overland via Collingwood, disheartened by the hardships awaiting them. Others next year came from the then-waning Aorere fields, and were more successful, working much ground in the lower Buller. In 1862 Lyell Creek was worked by a party of Maoris, but it was not until gold was discovered in the Greenstone River—at Maori Point—in 1864 that the West Coast can be considered to have established its name as a goldfield. Before this, however, the open lands of the Grey valley were occupied by settlers. Thus Samuel Mackley, who was with James Mackay when the purchase of the Native land was finally completed, settled with his family on the Waipuna Run in 1861. Isaac Freeth was on the Ahaura Plains with his headquarters near Raupo, and a man named Wood had the Little Grey Run. Later, in 1865, the Ahaura, Ohinetakitaki, and Ikamatua plains were acquired by Messrs. Pike and Saxton, and the Little Grey Run by Messrs. Fergusson and McHardy. This was the time of the Nobles – Little Grey "rush"; while Redman Creek, near Capleston, was not tried before 1866, and the lodes at Reefton were unknown till 1869.

PREVIOUS GEOLOGICAL OBSERVERS.

The late Sir Julius von Haast was the first geologist to examine any part of the Reefton Subdivision. His observations, made in 1860, are contained in the "Report of a Topographical and Geological Exploration of the Western Districts of the Nelson Province" (1861), and embodied in a map in "Von Hochstetter's and Petermann's Geological and Topographical Atlas of New Zealand" (1864). From such an exploratory survey anything more than a meagre sketch of the geology could not be expected, and for a fuller exposition of von Haast's views his "Geology of Canterbury and Westland" (1879), although dealing with another area, should be consulted.

The late Sir James Hector visited the coastal region of the subdivision in 1867, and in his report gave a classification of the detrital gold-deposits, with which all subsequent observers are in substantial accord. Subsequently he paid several visits to the mining districts of the West Coast, but did not visit Reefton till December, 1873, when he examined the Devonian rocks and such mining properties as had then been discovered. In many publications Sir James, furnished from time to time with new facts by his field officers, gave expression to his opinions on the geology of the districts ; and to these, of which a list appears below, the reader is referred.

Late in 1875 Mr. S. Herbert Cox, accompanied by Mr. Alexander McKay, made a reconnaissance survey of part of the Reefton Subdivision. In his report he discusses the relationship of the Devonian rocks to the auriferous series, which he correlates with the Maitai Formation. He also makes valuable remarks anent the economic geology of the district.

Mr. McKay examined the Reefton and Inangahua districts in some detail in 1874 and again in 1882. His second report contains a masterly description of the general and economic geology of the area as then known. In later years he visited the West Coast on many occasions, and in 1895 published a general account of the region, in which much attention is given to the auriferous alluvial deposits, and in which his former conclusions, with slight modifications, are reaffirmed.

BIBLIOGRAPHY.

Since the date of the earliest gold discoveries on the West Coast numerous papers and reports dealing with the geology and mining industry of parts of the Reefton Subdivision have appeared. So far as the more important of these are concerned, the following list is believed to be fairly complete :—

The abbreviations used are—

Trans. : "Transactions of the New Zealand Institute."

Rep. G.S. : "Reports of the Geological Survey of New Zealand."

Mines Report : The annual volume published by the Mines Department of New Zealand.

A capital letter followed by a figure (thus, C.–3) refers to a New Zealand parliamentary paper.

1849. "Mr. Brunner's Late Exploring Expedition." *The New Zealand Journal*, vol. ix, Nos. 244 and 254, pp. 80–82 and 197–198. Reprinted (with considerable omissions) from the *Nelson Examiner.*

1851. Brunner, Thomas : "Journal of an Expedition to explore the Interior of the Middle Island of New Zealand." *Journal of the Royal Geographical Society*, vol. xx, 1851, pp. 344–378.

1861. Haast, Julius von : "Report of a Topographical and Geological Exploration of the Western Districts of the Nelson Province, New Zealand."

1862. Rochfort, John : "Journal of Two Expeditions to the West Coast of the Middle Island of New Zealand." *Journal of the Royal Geographical Society*, vol. xxxii.

1867. Hector, James : "Abstract Report on the Progress of the Geological Survey of New Zealand during 1866–67," pp. 13–15. In this report a description and classification of the gold-bearing alluvium of the West Coast is given.

1868. Hector, James : Rep. G.S., No. 4, pp. 28–34. A reprint of the last-mentioned report (with slight alterations).

1870. Hector, James : "Mining in New Zealand." Trans., vol. ii, pp. 361–384.

1870. Hector, James : "Preliminary Notes on the Bones of a Fossil Penguin." Trans., vol. ii, p. 403. The bones were found on Seal Island, near Brighton.

1872. Hector, James : "On the Remains of a Gigantic Penguin (*Palæeudyptes antarcticus*, Huxley) from the Tertiary Rocks of the West Coast of Nelson." Trans., vol. iv, pp. 341–346.

1872. Hector, James : "Report on the Coal-mines in the Western District of the Province of Nelson." Rep. G.S. during 1871–72, No. 7, pp. 129–141, especially p. 134.

1872. Hector, James : "General Report on the Coals of New Zealand." *Ibid.*, pp. 172–181 Analyses of Murray Creek and Brighton coals are given on p. 176.

1872. Hutton, F. W.: "Synopsis of the Younger Formations of New Zealand." *Ibid.*, pp. 182–184.

1873. Hector, James: "Further Notice of Bones of a Fossil Penguin (*Palæeudyptes antarcticus*, Huxley)." Trans., vol. v, pp. 438–439.

1873. Hutton, F. W.: "Catalogue of the Tertiary *Mollusca* and *Echinodermata* of New Zealand." Many of the species described were collected near Brighton.

1873. Hutton, F. W.: "Synopsis of the Younger Formations of New Zealand." *Quarterly Journal of the Geological Society*, vol. xxix, pp. 372–379. Hutton classes the rocks of Brighton in the Ototara Group of Eocene age.

1873. H.–7, pp. 13–21. Reports of the Goldfields Wardens.

1874. Hector, James: "New Zealand Geological Sketch-map, constructed from Official Surveys and the Exploration of Dr. F. von Hochstetter, Dr. J. von Haast, and Others."

1874. H.–9, pp. 8–16. Reports of the Goldfields Wardens.

1875. Dobson, A. D.: "On the Date of the Glacial Period; a Comparison of Views represented in Papers published in the 'Transactions of the New Zealand Institute,' Vols. v and vi." Trans., vol. vii, pp. 440–446. Mention is made of the raised beaches at Brighton and Charleston.

1875. H.–3, pp. 9–13. Reports of the Goldfields Wardens.

1876. Woodward, H.: "On a New Fossil Crab from the Tertiary of New Zealand." *Quarterly Journal of the Geological Society*, vol. xxxii, pp. 51–56. The crab was collected from Seal Island, near Brighton. In a note by Dr. Hector a classification of the Mesozoic and Cainozoic beds in New Zealand is given.

1876. H.–3, pp. 18–20. Reports of the Goldfields Wardens.

1877. Hector, James: "Progress Reports." Rep. G.S. during 1873–74, No. 8, pp. xiv–xvi. Sections along the Inangahua and Fox rivers are shown.

1877. McKay, Alexander: "Reports relative to Collections of Fossils made on the West Coast District, South Island." *Ibid.*, pp. 74–115. Pages 84 to 102 and 107 to 111 deal with the Reefton Subdivision. An unconformity in the Tertiary sequence near the mouth of the Fox is mentioned on page 108.

1877. Hector, James: "On a New Trilobite (*Homalonotus expansus*)." Trans., vol. ix, p. 602. Collected from the Devonian rocks of Reefton.

1877. Hector, James: "Progress Report, 1874–76." Rep. G.S. during 1874–76, No. 9. On p. ix Hector states that the sandstones of Seal Rock, Brighton, underlie the Cobden limestone.

1877. McKay, A.: "Report on Weka Pass and Buller Districts." *Ibid.*, pp. 36–42.

1877. Cox, S. Herbert: "Report on Westland District." *Ibid.*, pp. 63–93. Facing page 66 is a map and sections.

1877. H.–1, p. 13. Reports of the Goldfields Wardens.

1878. Cox, S. Herbert: "The Energetic Colliery, Reefton." Rep. G.S. during 1877–78, No. 11, p. 174.

1878. Hector, James: Appendices giving a List of Localities where Fossils have been found. *Ibid.*, pp. 189–210.

1878. H.–4, pp. 9–11. Reports of the Goldfields Wardens.

1879. Hector, James: "Handbook of New Zealand." This book was issued for distribution at the Sydney International Exhibition, 1879. Further editions were published in 1880, 1883, and 1886. There are brief references to the geology of parts of the Reefton Subdivision on pages 20 to 43.

1879. Hector, James: "Progress Report, 1878–79." Rep. G.S. during 1878–79, No. 12, pp. 1–17. A brief outline of New Zealand geology is given.

1879. H.–11, pp. 15–18. Reports of the Goldfields Wardens.

1880. H.–26, pp. 14–21. Reports of the Goldfields Wardens. Mr. Warden Mackay gives an excellent account of alluvial mining near Barrytown.

1881. Hector, James: "On the Distribution of the Auriferous Cements in New Zealand." Trans., vol. xiii, p. 429.

1881. H.–17, pp. 22–27. Reports of the Goldfields Wardens.

1882. Hector, James: "Index to Fossiliferous Localities in New Zealand." Rep. G.S. during 1881, No. 1A, pp. 118–128.

1882. Cox, S. Herbert: "Notes on the Mineralogy of New Zealand." Trans., vol. xiv, pp. 418–450. The writer mentions stibnite, cassiterite, and spathic iron as occurring in the Reefton Subdivision.

1882. H.–19, pp. 21–26. Reports of the Goldfields Wardens.

1883. Hector James: "Progress Report, 1882." Rep. G.S. during 1882, No. 15, pp. xxii–xxx. Compares the Devonian rocks of Reefton with the Silurian of Baton River.

1883. McKay, A.: "On an Antimony Lode at Reefton, Inangahua County." *Ibid.*, pp. 88–90.

1883. McKay, A.: "On the Geology of the Reefton District, Inangahua County." *Ibid.*, pp. 91–153.

1883. Cox, S. Herbert: "Notes on the Mineralogy of New Zealand." Trans., vol. xv, pp. 361–409. Mentions the coals and limestones of the Reefton Subdivision.

1883. H.–5. Reports of the Goldfields Wardens.

1884. Hector, James: "Progress Report, 1883." Rep. G.S. during 1883–84, No. 16, pp. xii–xv. Table of the sedimentary rocks of New Zealand.

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CHAPTER II.

CULTURE.

POPULATION.

The Reefton Subdivision contains most of Inangahua County, including the whole of its inhabited portion, as well as parts of the counties of Buller and Grey. According to the census of 1911, 4,503 people lived in Inangahua County, while for those parts of Buller and Grey counties within the subdivision the writer estimates a population of 100 and 350 respectively. Thus the total population of the subdivision in 1911 was probably slightly under 5,000.

The only town of the subdivision, Reefton, with about 1,800 inhabitants, is built on the flood-plain and low terraces of the Inangahua at its debouchure from its lower gorge. It has an excellent water-supply and drainage system, and is lighted by electricity generated by water drawn from the river. Reefton, which is forty-seven miles by rail from the port of Greymouth, acts as a distributing-centre for several small townships near it, such as Black's Point and Crushington on the Inangahua, Soldiers, Progress Junction, Globe Mine, and Big River to the south, and Cronadun, Capleston, and Inangahua Junction to the north. Inangahua Junction and Cronadun are small villages in the rising agricultural districts of the middle Buller and Inangahua valleys, whilst the others are mining townships. In the Grey valley on the railway-line are Ikamatua and Totara Flat. The former, with two large sawmills close at hand, acts as a distributing-centre for the growing townships of Hukarere, Blackwater, and Waiuta, while Totara Flat, the centre of one of the richest agricultural districts on the West Coast, discharges this function for the once-important alluvial-mining townships of Granville and Nobles. As places of departure for the upper Grey valley, Ikamatua and Totara Flat are equally convenient. On the coastal district Barrytown is the only township; alluvial mining is still carried on in its neighbourhood, but agriculture is likely to have an increasing importance.

In the old days mushroom townships sprang up at each alluvial "rush." Some, like Soldiers, Blackwater, Granville, Moonlight, and Barrytown, are still in existence; others, such as St. Kilda and Brighton on the coast-line, Upper Blackball, Nobles, Adamstown, Squaretown, Antonio's Flat, and Maori Gully in the Grey basin, Cement Town and Landing Creek in the Inangahua valley, are now little more than names. Townships placed conveniently to lode-mines have usually proved to be more permanent, but of these Merrijigs is decadent, while Kirwan's Hill and Colinton (on Larry Creek) are quite deserted. In the "sixties" the river-beds were the main roads of the subdivision, and near them were established distributing-centres for the miners who toiled in the back gullies. In the Grey valley these centres were Totara Flat and Squaretown, the latter situated near where the Maimai Railway-station now stands. In the Inangahua valley were Inangahua Junction and Kynnersley.* At that time the low hills between the Mawheraiti and Inangahua were crossed by a pack-track that followed the former stream nearly to its head, and entered the Inangahua fall by way of Donkey Creek. Kynnersley, situated on the north bank of the Waitahu, near the present railway-bridge, was conveniently situated for traffic from the Grey valley, but the early discovery of the auriferous lodes of Murray Creek and the Inangahua valley led to its abandonment for the new township of Reefton, while Cronadun absorbed the function of distributing-centre for the alluvial diggings of Boatman, Larry, and Landing creeks.

By far the greater part of the population of the subdivision has always been directly dependent on mining for a livelihood. At first alluvial digging supported the bulk, but now, and for a long time past, lode-mining has required the greater number of workers. The writer does not anticipate any diminution of the number so employed for many years to come. It is probable, however, that before long the coal-mining industry will assume as great if not greater proportions than the present lode-mining. The timber industry of the subdivision now employs as many workmen as it ever did or is likely to do. Agriculture, although it will never attain the importance reached in districts more favoured by soil and climate, ought in the future to engage an increasing number of people.

MEANS OF COMMUNICATION.

The Reefton Subdivision possesses no seaport, and communication with the rest of New Zealand is maintained by railway and road. The Midland Railway, which connects with the bar harbour of Greymouth, enters the subdivision at the south-west corner of Mawheraiti Survey District, continues along the valley of the Grey and Mawheraiti, and crosses a low saddle near Reefton into the basin of the Inangahua. The line has been constructed down this valley as far as Inangahua Junction, a distance of twenty miles. Ultimately it is intended to extend the line both down the Buller to link with the railway creeping along the river from Westport (forty-nine miles from Reefton) and up the Buller to connect with the Nelson system, which now ends at Glenhope (seventy-four miles from Reefton). Meanwhile a motor service from and to Reefton is maintained over excellent roads, that with Westport being daily and that with Glenhope thrice weekly. Two trains run daily to Greymouth, and at Stillwater Junction connection is made with the tri-weekly Greymouth–Christchurch service over Arthur's Pass.

The subdivision is well roaded, and everywhere macadamizing-material is abundant. In addition to the undermentioned roads and tracks, the tramways of the various sawmilling companies often afford ready access to localities otherwise difficult. From Reefton four main roads radiate. One follows the Inangahua to its junction with the Buller, whence branches go down that river to Westport and up it to Nelson and Blenheim. Another follows the Inangahua to its source, and, crossing the Rahu Saddle, reaches the Maruia Plain from which the traveller may either proceed down-stream to Murchison or go up the valley to Canterbury. The third important road serves the mining townships of Soldiers, Progress Junction, Merrijigs, and Big River. The fourth road crosses a saddle into the basin of the Mawheraiti, and follows the railway to Greymouth.

Numerous roads and tracks leave these main arteries, but of these only a few deserve mention, the position and course of the others being sufficiently indicated on the maps. About five miles north of Three-channel Flat Post-office a track climbs to the ridge in the great bend of the Buller, and reaches the alpine meadow of

* The township-site at the mouth of the Mokihinui River, twenty-five miles north of Westport, is also called Kynnersley. Both places were named after the late Caleb Kynnersley, the first Warden of the Nelson goldfield.

Boundary Peak. At one time it was intended to extend this track to Kirwan Hill by way of the forest-bare country round the head of Larry Creek. At Three-channel Flat a cage across the Buller connects with a bridle-track that leads to Welshman pakihi, and finally goes out of the subdivision on its way to the Orikaka valley. What is known as Crook Road leaves the main Nelson Road about half a mile from the Inangahua, and follows the eastern side of the valley to The Landing, where it rejoins the main Inangahua Road. From Cronadun a road leads up Boatman Creek to Capleston, whence one track continues up the creek to Kirwan Hill while another gives access to the upper valley of Larry Creek. From the Reefton–Greymouth Road a branch ascends the Blackwater River valley to the mining townships of Blackwater and Waiuta, from the latter of which a bridle-track leads to the Big River. An old digger's track—Quigley's Track—leaves the road at the Big River junction, and, after following that stream for several miles, rises to the plateau country at the heads of Antonio and Slab Hut creeks, reaches Maori Gully, from whence it descends into Devil Creek and joins the Progress Road. The principal highway up the Big Grey is along the south bank of that river for many miles, first as a road and then as a pack-track, which ultimately leads to the great valley between the Spenser and Victoria mountains. To reach the settlers on the western bank of the Grey it is necessary either to cross the river west of Ahaura (where there is a ferry) or to take the road from Blackball, where the Grey is bridged. This road reaches as far north as opposite Raupo, and pack-tracks leave it for the upper valleys of Blackball, Moonlight, and Freeth streams, ultimately in all cases attaining the grassy uplands of the Paparoa Range.

Communication between Westport and Greymouth along the coast is possible only by horse or on foot. Vehicles may be taken from the south as far as the Punakaiki River and from the north to the steep descent of Tuhinu Hill, near Brighton. These points are connected by a pack-track following the shore, and in part widened to a road. Until recently traffic from the Punakaiki to the Fox River was along what is known as the "Inland Road," a bridle-track which gives access to and follows a depression between the mountains and the coastal hills of this region. One other track deserves mention, which, starting from without the subdivision, leads along the Four-mile Stream to the foot of the Paparoa Mountains. At one time it was intended to form this track right across the range by way of the Waitakere–Gordon saddle, but this useless undertaking was abandoned many years ago.

WATER-RACES AND DAMS.

The power requirements of the stamp mills are largely satisfied by the utilization of the abundant water-power of the district. The most important work so far undertaken for this purpose is the Progress race, which is over ten miles in length, and draws water from the Inangahua River capable of developing sufficient power to drive all the machinery of a 65-stamp mill. Other notable races are those in connection with the crushing plants of the Wealth of Nations, Keep-it-Dark, Big River, and Blackwater mines. As a consequence of the closing-down of unprofitable or apparently worked-out mines, the races used to convey power-water for their crushing plants have been allowed to fall into disrepair, as in the case of Anderson's, Caledonian, Just-in-Time, Kirwan's Reward, Golden Lead, Minerva, Crœsus, and Garden Gully batteries. Formerly water-power was extensively used for winding in shafts—for instance, in the Caledonian, Fiery Cross, Wealth of Nations, Keep-it-Dark, Globe, and Big River mines—but now only one plant of this nature is in operation—namely, that at the Golden Point Mine. Power for the Mawheraiti sawmill is drawn from Stony Creek, and De Filippi's sawmill is similarly driven from Flaxbush Creek. Part of the power required by the electric-light plant at Reefton is supplied by a turbine driven by water from the Inangahua River.

In the early days of alluvial mining innumerable races were constructed by the diggers for sluicing purposes. These were usually small, and the water they carried was used to remove tailings rather than break down the wash. In later years larger races at higher levels were constructed for hydraulic sluicing. Important works, for purposes ranging from mere ground-sluicing to elevating, are Howell's race near Capleston, Sewell's race at Merrijigs, Baybutt's race near Granville, Jenkin's race at Garden Gully, Wessel's and Perotti's races at Upper Blackball, and the Canoe Creek and Baker Creek races near Barrytown. The race from the Roaring Meg Stream, which commands the Healy Gully gravels, also has its head in the subdivision. In connection with the Upper Blackball races it should be mentioned that a tunnel has been driven through the low spur separating the Roaring Meg from the Blackball, and it is possible to divert the former stream through it down the Blackball.

Small races to supply water for domestic purposes exist at Lyell, Capleston, and Reefton, while a much more ambitious scheme is projected to tap the Ten-mile Creek in order to provide a high-pressure service for the Greymouth Borough, which at present depends on water pumped from the Grey River.

The old diggers, in order to further sluicing operations, often constructed dams in creeks or on terraces, but of these usually only traces now remain. In later times dams have also been built to conserve water for boiler-feed, for ore-crushing, or for power purposes. Of these the largest dam is that at the head of the Big River, which contains water to augment the power-supply at the Big River battery during dry weather.

INDUSTRIES.

Introduction.

Although the first white inhabitants of the subdivision settled as graziers on the open terraces of the Grey valley, the discovery of rich alluvial gold which took place a few years later was the chief factor in increasing the population and opening up the district. Gold-quartz mining soon came into prominence and gave a permanence to the mining industry, which alluvial digging alone could not guarantee. Coal-mining sprang up as an adjunct to lode-mining, on the prosperity of which its existence in this subdivision is still almost entirely dependent. Similarly the prosperity of the timber industry is to a large extent based on the lumber consumed by the gold-quartz mines and the community they support. Agriculture, though making progress, is not in a forward state, and it is probable that a great deal of produce will always require to be imported to supply the needs of the mining population.

General and Historical Account of the Mining Industry.

The Mining of Detrital Gold.

Payable gold was first found on the West Coast in 1859, by the Maoris of John Rochfort's survey party, at the "Old Diggings" on the north bank of the Buller, within or near the boundary of the Reefton Subdivision. This locality and the Buller valley below it were worked with some success in 1860–61 by miners from the Collingwood goldfield. The next important workings were in the basin of Lyell Creek, from which in 1862 a party of Maoris got a considerable quantity of coarse gold. It is probable that during these years a portion of the Buller valley between Lyell Creek and Old Diggings, as well as the lower Inangahua basin,* also received

* Hochstetter and Petermann's map of Nelson, published in 1864, shows numerous gold-workings between Lyell and Inangahua Junction.

attention from prospectors, but of this there seems to be no record, and certainly no important find was made. It was not until the discovery and exploitation of the Greenstone and Waimea goldfields during 1864–65 that the West Coast established the reputation of being an important goldfield. The year 1865 saw prospectors, using Hokitika and Blaketown (now part of Greymouth) as centres, searching every gully in the surrounding districts. In July of that year No Town, Red Jack, Nelson, Callaghan, and Blackball creeks were prospected, the latter in August yielding to a Maori a 22 oz. nugget. It was early in 1865 that George Moonlight, travelling overland from Westport to the Grey valley "rush," descended from the ridges of the Paparoas into the stream which bears his name, and found rich gold-bearing wash in the creek-bed near the present township. Next year the discovery of two nuggets, of 78 oz. and 79 oz. respectively, in this creek is recorded. In March, 1866, there were "rushes" still farther up the Grey. Duffer, Nobles, Snowy, Blackwater, and Antonio creeks became famous, and by May a thousand miners were in the Little Grey valley. In April of the same year prospectors reached Maori Gully, a small branch of Slab Hut Creek, and in the early spring Redman found payable wash in the tributary of Boatman Creek that bears his name. Other discoveries were quickly made, and soon Little Landing, Frying-pan, Flower, Soldier, Murray, Lankey, and Rainy creeks were being energetically worked. Boatman Creek owes its name to the fact that a party of boatmen, who had brought a load of provisions from Westport to The Landing, found rich gold-bearing gravel in that stream.

In 1866 the beach leads and raised beaches, so rich in the Waimea district, were traced northward from Greymouth along the coast as far as the Seventeen-mile Beach and Canoe Creek. About this time also the Westport district, which had been rather neglected for the more favoured fields of Westland and the Grey valley, began to receive more attention, and the rich marine gravels south of the Buller were discovered. This was a most important "rush," and by October twelve hundred men were working near Charleston. Then came the find at the Fox River, and within a week thousands of diggers, it is said, were camped on the beach between Brighton and St. Kilda. By December the leads had been traced as far south as the Gentle Annie Rocks.

This year saw the general boundaries of the auriferous areas on the West Coast approximately known. The gold-yield soon declined, at first rapidly, but in a few years more slowly, as the decrease in the cost of living, brought about by the improvement of the means of communication, enabled ground unpayable at first to be profitably worked. Discoveries of new ground in old fields prolonged their life. Such discoveries were made on the high terraces at Razorback in 1871, at Teviot and Blackball creeks in 1873, and at Half-ounce and Redman creeks in 1874. Henceforth the Chinese, who had appeared in considerable numbers in 1874, increasingly occupied the diggings in the Grey and Inangahua valleys, and with patience and industry worked for profitable return many a creek and flat abandoned as too poor by the white digger. In 1879 alluvial mining in the vicinity of Reefton received a new impetus through Edward Carton's discovery of the rich deposits on a terrace of the creek to which the writer has given his name. This led to the reopening of Maori Gully and of the upper basin of Slab Hut Creek, and also indirectly to the working of much new ground in Burk Creek and Italian Gully near Capleston. Another find of importance was reported in September of the same year by R. H. Wessels, who discovered the Barrytown lead, in which locality within a year more than three hundred men were at work. In December of 1880 McIntosh and party found rich gold in Welshman Creek. Unlike the finds at Maori Gully and Barrytown, which maintained a large output for many years, this locality was soon almost deserted. A year or two later the wash in the limestone caves a mile to the north of

Inangahua Junction was being actively sluiced. In 1883 Slaty Creek in the Grey valley was worked; and in 1888 John Gill discovered the auriferous wash of Shellback Creek, a locality which for many years supported a considerable number of miners, chiefly Chinese. Since then, however, no important new finds have been made, and the yield has been slowly and surely declining. Young men are no longer attracted by the industry, which offers but a precarious livelihood, and from which the hope of sudden fortune has all but disappeared. Old men who followed the "rushes" in the early days, unable now to engage in a new occupation, eke out their pensions by getting a few ounces of gold in the back gullies, but the chief sources of alluvial gold are now sluicing claims and dredges.

Even before the "eighties" the necessity of expending much capital without getting an immediate return was recognized. Large working-parties, often backed by storekeepers, were formed for the purpose of bringing in water-races to command otherwise unworkable ground. Notable examples were the large sluicing claims at one time operating in Soldier and Devil creeks, quite close to Reefton. Later, companies were registered for the same objects, and the yield of alluvial gold from such comparatively large concerns is now much greater than that from the small claims held by individual miners.

One form of mining for detrital gold, which at one time promised greatly to increase the gold-yield and to prolong the life of the industry almost indefinitely, was dredging. This method of mining has one great advantage over others, in that it does not require the auriferous deposit to be unwatered before exploitation. The first dredges had their stand on dry land, but the advantages of having the dredging-apparatus operated from a floating base were so obvious that the term "dredge" was soon restricted to such a machine. As early as 1883 a primitive spoon-dredge, worked from the land, was used with considerable success on the river-beaches below Lyell, but there is no record as to how long this method of work was employed. The first pontoon bucket-dredge used in the subdivision was built in 1891 by the Whitecliffs Company, and worked near Rocklands and Berlin's with poor results, while soon after starting the dredge was stranded and sold as a total wreck. Later this dredge, under different names and ownerships, worked on the Buller from Inangahua Junction to Three-channel Flat with varying fortunes. In 1898 its then owners, who for some time had been working at considerable profit, disposed of their machine most advantageously. The great success attending some Otago dredges about this time led to a dredging boom, the effects of which extended to the West Coast, so that by the end of 1902 seven dredges had been built on the middle Buller (between Lyell and Berlin's), two on Boatman Creek, and ten in that portion of the Grey basin within the subdivision, and of these some were already disastrous failures. In later years seven or eight more were built, chiefly in the Grey valley. Of all the dredges which have worked within the subdivision, only three have paid back the capital expended in their erection. Many on liquidation of the original company were sold to working-parties for a fraction of their first cost, but even after such a drastic writing-down of capital some still did not pay wages to their owners. Since 1905 the number of dredges working in the subdivision has been steadily decreasing, and at the present time (November, 1914) only four are in commission. It is proposed, however, to erect two more near the junction of Antonio Creek with the Mawheraiti. In this locality the Worksop dredge has been working for a number of years with conspicuous success.

The rich alluvial gold of Murray and Lankey creeks was quickly traced to its immediate source in the basal conglomerate of the Miocene coal-measures, and in 1870 batteries with wooden stamps shod with iron were at work at Cement Town, Murray Creek. The discovery of auriferous quartz lodes in the vicinity probably prevented the full exploitation of the "cement" there and at Lankey's. In the early "eighties" an iron battery was erected in Lankey Creek to treat the auriferous conglomerate, but this venture was a failure. Attempts to work similar deposits at Capleston also appear to have met with but indifferent success. Nothing further seems to have been done for twenty years, when the Lankey Creek "cement" was again attacked, and was worked desultorily until acquired by Bolitho Bros. in 1905, since when it has been energetically worked with fair success. In 1912 a new find of "cement" was made on Globe Hill, and the deposit was partly developed by the Progress Mines, but work thereon was soon suspended. Early in 1915, however, a five-head battery driven by an oil-engine was erected in Oriental Creek by the above-named company, and material taken from the continuation of the deposit in this stream has been crushed, but with unpayable results.

Lode-mining.

The coarse hackly nature of the gold occurring in Moonlight Creek, and the quartz-fragments which often adhere to it, early induced the diggers to look for quartz lodes in this locality. Richly auriferous float quartz was quickly discovered, and a company was formed in Christchurch in 1870. An eight-head battery was erected and some ore was crushed, but the efforts made to discover the lode from which the shoad came failed, and operations ceased.

It was not until 1870 that the lodes in the Reefton district were discovered, where the first find was made by James Kelly near the head of Murray Creek. Other claims on the "line of reef" or lode-channel were quickly pegged out: indeed, the first application was by Fred Westfield, but this the Warden disallowed in favour of Kelly's. Other "lines" were prospected in quick succession. Thus, in October, 1870, James Anderson found auriferous quartz on the "line" that bears his name; in November, J. G. Walshe located the Ajax Claim; and shortly after Adam Smith found the Wealth of Nations.

Two crushing plants had already been erected in 1870 for the treatment of the gold-bearing "cement" of Murray Creek, and at one of these in 1871 the first 80 tons of ore from "Kelly's Line" (Westfield's claim) was crushed.

The difficulties of transport in those days were enormous, and it was not until 1872 that efficient crushing-machines were at work. The order in which the early plants came into commission appears to have been as under:—

Machine.	Number of Stamps.	Power.	Date of Starting.
Ajax	15	Steam	May, 1872.
Westland	15	Steam	July, 1872.
Band of Hope	10	Water	October, 1872.
Anderson's	15	Water	December, 1872.
Wealth of Nations	15	Water	January, 1873.
Energetic	10	Water	February, 1873.

Extravagant expectations had been entertained, and the returns, although nowadays they would be considered on the whole most satisfactory, disappointed many of the investors; and a return of 5 oz. per ton from a small crushing by the Just-in-Time was most opportune. This claim, located by James Clark, is situated at Boatman Creek, on a "line" or lode-channel usually known as Thompson's, but first prospected by Axel Topfer in January, 1872. February of that year also saw the discovery of the Big Blow at Rainy Creek by Adams Bros., while in the same month Joseph

Potter found the Caledonian at Larry Creek. In 1873 the banks established branches at Reefton, which had hitherto been but a wayside stopping-place to Black's Point and Cement Town, the settlements at the foot and head of Murray Creek respectively.

Next year a battery was erected at Colinton, as the township at the Caledonian Mine at Larry Creek was called, and another, a public crushing or "customs" plant, at Crushington. In 1875 the Hopeful, Venus, and Keep-it-Dark began crushing, and for several years the whole district made steady progress, both in the amount of ore won and dividends paid. At this time the absence of arterial roads and the consequent high transport charges militated seriously against the advancement of the district. The usual charge on goods from Greymouth or Westport was £10 to £12 per ton, while in winter transport-costs were 50 per cent. higher, and after a few days' rain all deliveries ceased. In 1877 the main road up the Buller from Westport to Reefton and Nelson was completed, while on the Grey valley road the bridging of the Ahaura, Big Grey, and Mawheraiti rivers was not finished till late in 1878. The cost of living was still further reduced in 1879 by the opening of a stock-track from Reefton to the Maruia Plain by way of the Inangahua and Rahu valleys.

Meanwhile other claims became producers, the Rainy Creek in 1876 and the Golden Treasure in 1879. New Zealand went through a period of financial stringency in 1878, and more particularly 1879, and this depression was accentuated in Reefton by the temporary failure of some of the principal mines. Matters improved next year; and a scheme which had been talked of for several years — namely, a low-level tunnel from Black's Point through the range to the Waitahu—was started. In this year also a track was opened to the head of the Big River. In 1881 rock-boring machines were introduced by the Golden Fleece Company, which in the following year also obtained a diamond drill. The returns from the Welcome Claim, consistently rich for many years, led to great activity in the Boatman's district. As it was evident that this shoot of phenomenally high-grade ore would shortly leave the Welcome ground, two projects were initiated to tap it at greater depths—the Eureka incline and the Specimen Hill low-level tunnel. The Inkerman Company, which before this had had its ore crushed at the Rainy Creek battery, now erected a 30-head mill of its own, the largest and most complete crushing plant in the district. New Zealand at this time was enjoying a period of prosperity, and this, combined with the excellent returns from many of the properties at Reefton, brought about a mining boom. The Big River, Merrijigs, Globe Hill, and Auld Creek areas now received attention. But although money was found for many legitimate propositions, a great deal was wasted on ventures obviously hopeless from the outset. In due time the penalty of overspeculation was paid, and the depression that followed was long-continued and severe. For several years the companies formed to work the lodes found during the boom were unsuccessful. Thus the Globe, formed in 1882, was on the verge of liquidation in 1886, when good ore was struck. The neighbouring Oriental Company was in worse case, for the claim had been sold for a trifling sum shortly prior to the discovery of the rich quartz in the claim just mentioned. This was later traced into the property, and worked by the Progress Company with conspicuous success for many years. During the summer of 1887–88 the Merrijigs district came into great prominence, and several promising ore-shoots were found, but the best claim, the Cumberland, was not discovered until 1890. In the later "eighties" the returns from the Boatman's mines greatly decreased, the gold-yield from the district being maintained by the Crushington lodes, and later by those of Devil Creek. The cyanide process was first used on the Reefton field in 1892. Before this many of the companies had allowed their tailings to be carried down the sludge-channels, the resulting loss being represented by many hundred thousands of pounds. At first the new process was not an unqualified success, the antimony sulphide contained in the ores seriously militating against satisfactory extraction, but in later years this difficulty was largely overcome.

TABLE SHOWING ANNUAL RETURNS FROM THE QUARTZ LODES OF THE REEFTON SUBDIVISION.

Year ended	Ore crushed.	Yield.	Value.	Calls.	Dividends.
	Tons.	Oz.	£ s. d.	£ s. d.	£ s. d.
March 31st, 1872 ..	10	42	163 0 0	..	..
1873 ..	6,480	6,737	26,106 0 0	..	..
1874 ..	16,223	15,542	59,968 0 1	..	..
1875 ..	22,310	18,340	71,067 0 0	..	12,944 6 8
1876 ..	33,064	24,278	94,077 0 0	..	27,513 0 0
1877 ..	33,969	30,628	118,684 0 0	..	50,612 10 0
1878 ..	41,947	36,691	142,178 0 0	28,702 0 0	63,508 6 8
1879 ..	28,070	26,023	100,864 0 0	..	22,465 0 0
1880 ..	28,062	18,090	70,099 0 0	..	..
1881 ..	25,926	17,802	68,541 11 0	10,218 17 6	19,650 0 0
1882 ..	14,894	20,154	77,844 16 6	25,054 3 4	37,643 15 0
1883 ..	18,928	19,194	74,656 16 9	61,344 15 0	32,600 0 0
1884 ..	23,433	16,547	64,456 7 5	49,456 5 0	16,500 0 0
1885 ..	34,349	23,997	93,842 7 1	29,333 6 8	34,100 0 0
1886 ..	27,198	14,591	56,622 9 0	24,565 2 1	14,500 0 0
1887 ..	23,930	21,143	83,170 15 5	21,596 6 8	33,450 0 0
1888 ..	24,403	16,775	66,030 11 5	30,432 5 10	17,550 0 0
1889 ..	28,565	18,663	72,720 18 0	38,918 15 0	16,687 10 0
1890 ..	32,394	17,780	69,676 12 1	27,531 6 8	18,250 0 0
1891 ..	39,787	23,347	91,998 8 10	20,404 3 4	27,325 0 0
1892 ..	35,562	23,390	93,885 5 1	25,956 10 0	30,743 0 0
1893 ..	37,693	20,171	80,894 5 1	18,799 15 10	16,900 0 0
1894 ..	34,518	18,413	73,752 14 11	14,350 0 0	18,832 0 0
1895 ..	26,603	13,427	53,509 5 1	10,153 6 8	11,012 10 0
1896 ..	29,816	16,604	66,793 10 6	8,418 0 0	25,925 0 0
1897 ..	13,267	8,365	33,824 7 1	9,033 6 8	4,900 0 0
1898 ..	9,751	4,266	18,253 7 3	7,859 3 4	50 0 0
1899 ..	42,305	21,488	87,587 1 0	5,920 6 8	900 0 0
1900 ..	58,277	26,693	108,455 17 8	10,747 8 9	47,050 0 0
1901 ..	82,618	33,979	134,557 7 11	5,824 9 7	35,300 0 0
December 31st, 1901 ..	97,870	46,067	186,719 5 7	6,233 6 8	58,199 18 0
1902 ..	98,485	46,561	188,655 2 5	6,900 0 0	63,974 0 0
1903 ..	109,571	48,840	195,468 16 10	4,587 0 0	57,641 0 0
1904 ..	117,380	52,094	204,472 13 10	5,262 0 0	54,674 0 0
1905 ..	113,158	46,211	180,942 16 7	3,870 0 0	55,343 0 0
1906 ..	88,530	40,990	159,807 5 11	1,995 16 8	57,826 0 0
1907 ..	95,542	39,878	153,242 1 5	..	39,175 0 0
1908 ..	91,283	39,601	151,529 11 8	..	16,600 0 0
1909 ..	101,127	53,121	201,971 0 4	..	43,955 0 0
1910 ..	121,105	59,792	229,314 14 10	..	53,212 0 0
1911 ..	126,067	57,260	222,839 17 1	..	50,696 0 0
1912 ..	49,922	28,004	107,032 16 4	..	15,600 0 0
1913 ..	116,813	49,778	194,300 3 4	..	26,900 0 0
1914 ..	130,770	57,865	229,205 4 6	..	22,100 0 0
1915 ..	132,250	54,076	217,559 10 6	..	24,999 0 0
Totals ..	2,464,225	1,293,298	5,077,341 16 4	..	1,277,806 16 4

For the years 1872 and 1874–80 inclusive the value is estimated by the writer.

In 1895 Mr. David Ziman, of Johannesburg, came to Reefton and acquired a great number of claims, which later were taken over by the Consolidated Goldfields of New Zealand, a powerful corporation that still dominates mining in the Reefton district. This company vigorously prospected its properties, a policy which soon bore abundant fruits. Modern methods were introduced, small claims were grouped, and, in spite of several unfortunate blunders of a class that indeed seem inherent to mining ventures, a satisfactory measure of success was achieved. In 1896 a group of mines in the Rainy Creek district was sold to an English company, and a great deal of money was expended in opening up the claims, but the developments were on the whole unsatisfactory, and after working for ten years the property was abandoned.

In December of 1896 an important find was made in a portion of the district hitherto unprospected. William Kirwan discovered loose auriferous quartz over an area of more than 10 acres on high country between the head of Boatman Creek and the north branch of the Waitahu. From the nature and position of the quartz it was evident that it had not travelled far, and vigorous but unsuccessful efforts were made to locate the lodes of which it had once formed part. A battery was erected in 1900, and until 1907 was regularly employed in crushing. In that year the loose quartz became exhausted, and although prospecting operations in this locality have continued without interruption up to the time of writing nothing of value has been disclosed.

In November of 1905 William Martin, a member of a Government-subsidized party, made an important discovery in the basin of Blackwater Creek, in which locality years before the Snowy Creek Gold-mining Company had worked a lode without success. The claim, together with several other neighbouring areas, was finally acquired by the Blackwater Mines, a company that continues to exploit its property with success. Other claims in this locality are the Prohibition, Blackwater South, and Millerton, but these have not yet reached the producing stage.

MINING AND TREATMENT METHODS.

The uneven relief prevailing over the area in which the lodes are found nearly always has permitted the ore-bodies near the surface to be explored and extracted by means of adits. Later shafts are sunk, the sites for which are determined by the data obtained in the adit-workings and by the configuration of the country. Vertical shafts are preferred, although incline shafts have been sunk along the dip of the lode, the shape in both cases being rectangular. Timbering is always necessary, the box-set or lagging with 8 in. by 6 in. timbers being generally employed in the older shafts, which are usually 9 ft. by 4 ft. in the clear. In 1896 the frame-set was introduced by the Consolidated Goldfields Company in the large shafts, 12 ft. by 4½ ft. in the clear, sunk by them. The general opinion seems to favour the shaft supported by box-sets, as giving less trouble and expense in maintenance. The mines are dry, and whatever water finds its way from the surface through the old workings is controlled by bailing, and in only one mine—the Caledonian—has the problem been serious.

In the early mining days the levels projected from the shafts were 60 ft. apart, but the interval has gradually been extended until now it is usually about 150 ft. The drifts have just sufficient grade for drainage—say, a rise of 1 in 150—and require timbering, except where crossing solid greywacke or "sandstone" country. In size they are usually 5 ft. by 7 ft. in the clear, but where horse-traction is used these dimensions are slightly increased. The irregularity of the ore-deposits and the weakness of the walls permit of exploitation only by means of flat-backed stopes. The timbering of these, which is universally necessary, is effected, when the lode is 5 ft. or less in width, by stulls and caps and, in larger ore-bodies, by a modification of the square-set system. The timber is kept as close to the working-face as possible, and the walls are so treacherous and liable to swell that filling must be kept well up to the face; indeed, it is considered bad practice to leave more than one stope open.

Natural ventilation is sufficient, and much more care in the matter of the splitting of air-currents and the maintenance of return airways is now exercised than was the case a few years ago. A small Sirocco fan was installed at the Progress Mine some years ago, but its effect was not appreciable in the distant workings, being nullified by the choked and leaky condition of the main airways, and when these were attended to the fan was found to be unnecessary. The ventilation of long adits is effected by driving or exhausting the air through small galvanized-iron pipes by means of small fans, which are usually water-driven. At other times a water-blast or even only a jet is sufficient to effect the purpose. Small hand-power fans are still occasionally used for long levels underground, but the general use of compressed air in mines has greatly simplified this problem.

On the 14th March, 1904,* three men were poisoned by sulphuretted-hydrogen gas liberated by water contained in a winze in the Wealth of Nations Mine. The winze, which had been sunk four months previously, had partly filled with water; and, on tapping this by a borehole from the rise below, the water, supersaturated by pressure, gave off enough gas to render the air fatal to the men, who, on the first trickle being manifest, had evidently turned off the compressed air from the drill. At ordinary temperatures and pressures water dissolves from three to three and a half volumes of the gas, which according to J. D. Villarello† is fatal to human life when contained in air to the extent of 1·1 per cent., a proportion comparable with that obtained by Thenard.‡ On the 6th September, 1888,§ at the Inglewood Mine a gas-explosion led to a fatality, and there can be no doubt but that the admixture of sulphuretted hydrogen with air had produced the explosive charge. Other instances in which men have been overcome when engaged in bailing, though rare, are not unknown, and in a damp level the smell of sulphuretted hydrogen may often be detected on lifting an old sleeper. The gas is probably generated by the action of the sulphuric acid, produced by oxidation of the pyrites, on the sulphides contained in the ore and country rock, or it may arise from the action of decaying timber on sulphates contained in the water. Sulphuretted hydrogen readily decomposes, and it is probable that its presence in dangerous amount in the water filling old workings is a temporary phenomenon, and depends on an unusual combination of circumstances. Certainly, accumulations of water in old workings in the Reefton mines have been tapped on hundreds of occasions without the gas having been detected.

The late John Trennery, then managing director of the Golden Fleece, was instrumental in introducing air-driven rock-drills to the field. This was in 1881, and soon other compressing plants were installed in connection with the Welcome Mine, Specimen Hill low level, Eureka incline, and Keep-it-Dark Mine. These early installations were not nearly so efficient as the modern compressor plants erected by the Consolidated Goldfields and its subsidiary companies, and were scrapped after a few years even by claims that continued to be successfully worked. Nowadays air-drills are used for all manner of work underground, hammer-drills being preferred for rising and stoping.

At one time water-power, applied by means of big overshot wheels, was a favourite means of winding from shafts. This method was employed in the Caledonian, Fiery Cross, Just-in-Time, Wealth of Nations, Keep-it-Dark, Hercules, Globe, and Big River mines. As greater depth was attained and the amount of ore raised was increased the wheels were found to be too slow, and were discarded one by one in favour of steam plants. Occasionally compressed air was used for major winding operations. The old Progress Company hoisted from their underground shaft by this means for some years, but later brought in steam to the winch. The Consolidated Goldfields in their Golden Fleece Mine also used compressed air for winding, this installation being remarkable in that no receiver was employed, the two miles of piping between

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* C.–3, 1905, p. 18.

† Villarello, J. D.: "El Pozo de Petroleo de Dos Bocas." Parerg. Inst. Geo. de Mex., vol. 111, 1909, No. 1, p. 48. Quoted in *Economic Geology*, vol. 10, 1915, No. 3, p. 215.

‡ Roscoe and Schorlemmer: Treatise on Chemistry, 1905, vol. 1, p. 382.

§ C.–2, 1889, p. 118.

the compressor and the winch being a sufficient reservoir. Small air-winches are in common use in the mines for the hoisting of timber to the stopes, and of ore or rock from shafts and winzes.

Where possible the treatment plant is placed close to the main outlet of the mine. Frequently, however, the mill is not, for economic reasons, placed near the mine, and the surface communication is effected by ground or aerial tramways or by a combination of both. Aerial transport has always been popular, although only two installations are now in use—namely, those at the Progress and Big River mines. At the former a fixed-rope system with a locked-coil-carrying rope is used, while at the latter mine a single travelling rope is employed. The single travelling-rope system was also used in connection with the Kirwan's Reward, Venus, Scotia, Cumberland, Golden Lead, Crœsus, and Garden Gully claims. The aerial method of transport is peculiarly adapted for the rugged topography obtaining in the Reefton Subdivision; and it should be noted that in no instance has it failed mechanically, and, except in the case of the Big River and Scotia plants, where the difference in height of the terminals is not great, all the installations work or worked by the influence of gravity alone. At the Big River Mine a single horse supplies the additional requisite power.

The metallurgical treatment that was in vogue in the Reefton field in the early days, though simple, was far from efficient. The ore was hand-fed to the mortars and crushed by slow-running light stamps, the pulp escaping through punched gratings of coarse mesh. Inside and plate amalgamation were practised. Rough concentration by means of ripples, blanket strakes, and square buddles, followed by the grinding of the concentrates with mercury in berdans, seems to have been in use at a very early date. Some few of the early battery-managers recognized that all the gold in the ore was not saved by this treatment, and stacked the tailings, which were nevertheless, in general, regarded as worthless. Their value, however, was convincingly demonstrated by the Wealth of Nations Company, the prospecting operations of which for sixteen years were paid for in great part by gold obtained from the regrinding of tailings. Even later than this, however, the amount of gold unsaved by amalgamation was not generally appreciated.

In 1893 the Cassel Company erected an experimental cyanide plant at Capleston, but the amount of slimes and antimony sulphide contained in the tailings presented difficulties too great for the technical knowledge of that period. The first successful cyanide work was in connection with the accumulated tailings of the Big River and Cumberland mines in 1897–98. Since that date the cyaniding of sands has been general, and all accumulations of old tailings have now been treated. The great success attending the fine grinding of the ores of the Hauraki Goldfield induced the Consolidated Goldfields and Blackwater Mines companies to install tube mills, agitation-tanks, and slime-extraction plants. A better extraction was obtained, but the profit was less; and the plants erected are not now used, with the exception of the tube mills, which are fed with coarsely crushed pulp from the stamp mortars.

As already stated, the first attempts at concentration were very crude, and were effected by means of ripples, blanket strakes, and square buddles, the product in all cases being ground with mercury in berdans. In 1896 the Globe Company installed half a dozen Triumph concentrators, but the results were not encouraging, a fact probably due to bad adjustment of the machines, and their use was discontinued in the year after. The Progress Mines, the first of the Consolidated group to start crushing, had Frue vanners following the amalgamating-plates; and the Inkerman was equipped with Union vanners; but for the other mills of the district Wilfley tables have been adopted. A considerable proportion of the ore crushed is reduced to slime, the heavy minerals in which are neither caught by the concentrators nor settle in the cyanide-vats. To save them, the overflow from the vats is made to pass in a thin film over a wide surface of gently inclined tables, made either of cement or of wood covered with canvas. By this means a concentrate is caught on the table, and is washed off several times a day, and allowed to settle in slime-pits. This method of gold-saving was first tried in 1898 by the Progress Mines, which company later also installed a Wilfley slime-concentrator, but found it much less satisfactory than the tables.

The earliest method of treating the concentrates consisted of grinding them with mercury in a berdan. Sometimes the sulphides were subjected to a rough roast, and various chemicals were added to improve amalgamation ; while the more efficient grinder, the Fraser pan, was also tried in place of the berdan. In no case, however, were the results satisfactory. In 1899 the Progress Mines erected a roasting-furnace and chlorination plant, and for many years treated their concentrate by this method, while the other mines of the district shipped their product to Australian smelters. Owing to the amount of arsenic and antimony in the Reefton ores the chlorination process was not an unqualified success, the residue after treatment still containing about 30 dwt. of gold per ton. After exhaustive experiments in England it was decided to adopt a matte-smelting process, by which the many thousands of tons of chlorination residue stacked at the mill would be used as a flux to assist in the treatment of its current product. A Merton mechanical roasting-furnace and a reverberatory were erected, while the old chlorination furnace was converted into chambers for the condensation of the arsenical and antimonial fumes. The concentrate was partly roasted, and the charge to the reverberatory consisted of a mixture of roasted concentrate and slime, chlorination residue, and crushed limestone, together with a small amount of cupriferous concentrate* or matte from a previous smelting. A copper matte or speiss containing the whole of the gold resulted ; and this was recrushed and charged again to the furnace until the gold-content had reached a dangerous degree of concentration, when the matte, which should then have contained the whole of the gold and copper added, was sent to Australia for final treatment. Although theoretically this process is feasible, it failed commercially, owing, at least in part, to the absorption of copper and gold by the hearth,† and the furnace was shut down after a brief campaign. At the present time all the mines ship their concentrates to smelting plants in Australia ; in the case of the Progress Mines after a preliminary roasting, by which part of the sulphur, arsenic, and antimony are eliminated, and the transport and smelting charges thereby reduced. It must also be recorded that various attempts have been made to treat the concentrates by sliming and cyanidation, but these have all had to be abandoned.

At the present time the treatment of the ore is not materially different at the various mills, and follows the practice in vogue in other mining districts where ore of a similar nature is worked. The operations may be briefly described as follows : The ore from the mine is dumped on grizzlies, the fine material falling directly into the bins, and the coarse being broken by jaw-crushers before doing so. From the bins the ore passes by way of self-feeders to the mortars, which may or may not be fitted with chuck-blocks. At the Blackwater and Wealth of Nations mills the ore is crushed coarsely, the reduction to pulp of the requisite fineness being completed in tube mills. In these cases inside amalgamation is not practised, and there is a tendency throughout the district to employ only plate-amalgamation even where the mortar-screens are of the usual 15-mesh size. The pulp is then passed, first, over amalgamated copper plates and then over concentrators. At this point the pulp has nearly always to be

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* Obtained from Aniseed Valley Copper-mine (Nelson), and containing about 10 per cent. of copper.

† The hearth when broken up is reported to have yielded over £9,000 in gold.

elevated, wheels being used; it is then classified in V boxes, and conducted to the cyanide plant. In some cases the sand is collected in settling-vats, from which it is trucked to the treatment-tanks; in others the sand goes direct to the treatment-tanks, where revolving distributers are used, and the separation of the slime aided by forcing in water or compressed air below the filter-bed. Treatment lasts about a week, the advantages accruing from turning the sand being recognized. The slime from the V boxes and vats is conducted to the slimes plant, from which it runs generally to waste, although at some of the mills (Progress and Wealth of Nations) a considerable proportion is collected by settling in dams. The accompanying table shows the results attained by this method of treatment. The percentage of extraction varies cons'derably in total amount, and also in the proportion saved by each process. It should also be noted that the ordinary table concentrates contain from 4 oz. to 6 oz. of gold per ton, while the slime concentrates contain rather more than half these quantities.

——	Progress.*	Wealth of Nations.*	Blackwater.*	Keep-it-Dark.†	Golden Fleece.‡	Inkerman.§
Gold-content of ore by assay per ton	8·325 dwt.	8·804 dwt.	10·699 dwt.	..	..	..
Percentage recovered‖	78·99	86·12	89·42	..	..	..
By amalgamation	53·44	63·74	73·62	..	..	..
By cyanidation	12·50	19·18	8·30	..	..	..
By concentration	13·05	3·19	7·50	..	..	..
Percentage not recovered‖ ..	23·36	..	9·57	..	..	..
In cyanide residues	6·25	..	4·07	..	..	..
In slimes	17·11	..	5·50	..	..	..
Percentage of product recovered by amalgamation¶	67·50	74·00	82·30	64·00	81·00	69·00
By cyanidation¶	16·00	22·00	9·30	27·00	12·00	21·00
By concentration¶	16·50	4·00	8·40	9·00	7·00	10·00
Percentage of pulp cyanided¶ ..	67·60	64·20	56·30	..	67·70	72·20
Percentage of concentrate saved from ore¶	1·19	0·62	1·03	..	..	..

* From annual report of company for 1914. † Mines Report, C.–3, 1906, p. 50 (estimate only). ‡ *Ibid.*, p. 45. § Mines Report C.–3. 1905, p. 94. ‖ The discrepancies between these sets of figures are due to unavoidable errors in the sampling and measurement of ore, residues, &c. ¶ The figures for the Big River are respectively 83, 12·5, 4·5, 85, and 1·34.

The Reefton district as a gold-mining centre owes much to its timber, coal, and water supplies. Had the lodes of this area occurred in a treeless region it is certain that they would not have been worked to the same extent, and it behoves all those interested in mining in this district to conserve the by no means inexhaustible timber resources. For winding purposes steam is now universally employed, and the numerous patches of coal-bearing rock distributed over the area containing the lodes have proved of great value. Wood at one time was largely used in boilers, and still is to some extent at the Blackwater Mine. All the batteries at present working use water-power; that at the Blackwater having a supplementary suction-gas plant for use during periods of scanty rainfall. In the past several of the mills now idle were driven by steam plants, and that of the Murray Creek Mines is also to be so operated.

In conclusion it should be stated, in connection with the mining and milling practices, that Reefton is a comparatively old field, and the equipment of some of the mines and the methods employed are inclined to be obsolete. There is a natural tendency to ignore the experience of other mining districts in the requirements necessary to ensure economical mining, and to rely on methods that have proved successful on the

Reefton field. Such conservatism is right and proper when based on sound premises. The few incline shafts of the Reefton district have been sunk on the dip of the veins, and these have proved decidedly more difficult to maintain than the vertical shafts. For this reason all the main shafts are now of the latter type. On the other hand, the underground workings have shown that all the ore-shoots have a pitch to the north, and this in combination with the dip quickly alters the position of the ore-bodies in plan. Moreover, experience in other parts of the world—notably, in California, where the conditions approximate those prevailing at Reefton, and in the Transvaal, where they are altogether different—has proved that no insuperable difficulties exist in respect to the construction, maintenance, and working of incline shafts. The future of lode-mining in the Reefton district depends in great measure on the deep levels of the mines already proved, and even now the cost of the long crosscuts at each level is becoming onerous. An intelligent anticipation of the course of the ore-shoot is now possible, and incline shafts are certainly advisable. These, to be of the greatest service, should be placed some distance—say, 100 ft.—in the foot-wall of the lode, and should maintain the same relative position to the ore-shoot throughout. In South Africa some of the deep mines are approached by composite shafts; but it is doubtful if the existing vertical shafts could be converted to this type, and if inclined shafts are to be connected with them electrical winding plants are desirable in view of the inefficiency of winding by compressed air. The most convenient method of hoisting in incline shafts is by means of skips, and these could also be used in vertical shafts with advantage, and would materially increase their capacity. If considered necessary, swinging-guides could be provided on the poppet-heads to facilitate the interchanging of cage and skip. In connection with the use of electrical power there is little doubt but that the adoption of this flexible method of power-transmission from a central plant, with prime movers driven either by steam, gas, or water, would be conducive to economy; while if a successful electrical rock-drill were placed on the market the advantages accruing would probably lead to the scrapping of all the present compressing plants.

LABOUR CONDITIONS.

In the days of the first gold "rushes" each man either was an independent unit working alone or formed one of a party, with an interest equal to that of his mates. Frequently the individual or party had a storekeeper as sleeping-partner, who supplied stores up to a certain amount in lieu of labour. At other times, especially after the lapse of a few years, when it became possible to hire labour, the non-working partner paid a man to take his place. These partnership methods naturally were applied to the quartz claims when they were first prospected. When the mining operations necessary were beyond the capacity of the individuals or parties, and companies were formed to undertake them, the working-miner generally held scrip in the company controlling the claim on which he worked. This system of profit-sharing, although it led to many grave abuses when numerous small companies were at work, was undoubtedly a prime factor in preventing labour troubles. As far as the writer could ascertain, the only serious unrest during the last century occurred in 1875, when the mining companies, at a time when prospects looked very bad, reduced wages from £3 10s. to £3 per week, an alteration that did not continue long.

The Consolidated Goldfields of New Zealand started operations in the Reefton district in 1896, and, finding the local supply of labour insufficient for their needs, induced many miners to come from Australia. About this period also the West Australian and, to a less extent, the Hauraki mines absorbed a great deal of skilled labour; and these fields, although now past their zenith, still maintain great mining populations. In addition to this, Australasia as a whole, in common with the rest of the world, has during the past twenty years enjoyed prosperity hitherto unexampled. All these factors operate in the same direction, and have tended to decrease the amount of labour available for the mines ; and it is owing to the inevitable adjustments in the price to be paid for it and in the conditions under which it is performed that industrial disagreements have arisen. Of these disputes the strike of 1912 was much the most serious, involving as it did all the mines of the Consolidated group. The ostensible reason for this trouble was the attempt to introduce the Waugh hammer-drill, which the management contended required only one man to work, whilst the miners, on the other hand, considered two men necessary. The underlying principle involved, however, was the right of open contract desired by the owners, some time previously the miners' union having taken upon itself the fixing of the prices for all contracts. Finally, after eight months, a compromise was arranged whereby the union agreed not to interfere in the matter of contracting, while the mine-owners agreed to work hammer as well as other air drills with two men.

In common with other industries, mining is now called upon to pay its workmen decidedly higher wages than those current a dozen years ago. According to the Inangahua Gold-miners' award that came into force on the 17th November, 1913, the miner receives 11s. per shift of eight hours, and the trucker gets 10s., while a few years ago these rates were respectively 9s. 6d. and 8s. As far as possible work is done by contract, and this is universally the case in development, where the scope of the work required can be clearly defined. In stoping, however, the system is open to serious objections owing to the irregular shape of the ore-bodies and the flaky nature of their walls. Nevertheless, a good deal of the ore is so broken. The wages per shift earned by contractors in three of the principal mines during 1914 were as follows* :—

	Wealth of Nations.	Progress.	Blackwater.
	s. d.	s. d.	s. d.
Development contracts	15 11	17 8·26	17 3·60
Stoping contracts	16 11	18 5·93	17 3·28

* This and the other information following is taken from the 1914 annual reports of these companies.

MINING AND TREATMENT COSTS.

The only detailed cost-sheets available to the writer are those of the Blackwater, Progress, and Wealth of Nations mines, and the following tables are compiled from their annual reports for the year 1914 :—

Development-costs.

Mines.	Labour and Salaries.	Explosives.	Timber.	Sundry Stores.	Compressor.	Hoisting.	Miscellaneous.	Total Cost per Foot.
Blackwater—	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Driving (2,124 ft.) ..	30 1·69	2 6·96	3 3·91	2 0·30	2 8·91	3 7·88	3 7·84	48 1·49
Crosscutting (650 ft.) ..	22 1·34	3 1·80	..	..	2 3·79	3 11·64	5 11·55	37 6·12
Rising (1,151 ft.) ..	28 5·35	2 1·22	5 0·17	1 9·90	4 8·87	2 5·83	3 2·47	47 9·81
Progress—								
Driving (2,764 ft.) ..	31 9·84	4 8·65	4 6·70	2 10·45	1 9·38	..	8 6·37	54 3·39
Crosscutting (2,404 ft.) ..	31 0·05	4 4·20	3 4·89	3 5·87	1 9·65	..	6 5·95	50 6·61
Rising (1,059 ft.) ..	30 6·88	4 0·78	7 0·83	4 2·27	5 1·12	..	6 11·14	57 11·02
Winzing (42 ft.) ..	103 11·15	15 5·79	14 6·52	1 2·97	7 5·72	..	26 11·19	169 7·34
Diamond drilling (955 ft.)	5 2·35	...	..	5 6·99	1 3·54	..	0 3·42	12 4·30
Wealth of Nations—								
Driving (1,269 ft.) ..	34 5·66	4 8·53	4 2·31	2 8·72	3 4·14	..	11 5·41	60 10·77
Crosscutting (883 ft.) ..	33 5·70	4 6·14	1 8·01	3 11·33	2 6·80	..	8 0·26	54 2·24
Rising (1,297 ft.) ..	33 8·02	2 10·90	8 8·76	4 3·67	3 10·91	..	8 1·30	61 7·56
Winzing (44 ft.) ..	62 10·16	5 4·20	10 6·59	4 4·63	7 0·83	..	19 0·15	109 2·56

These costs are between 60 and 70 per cent. more than those of a dozen years ago.

For the same year the mining and treatment costs were as follows:—

MINING-COSTS.

—	Blackwater (49,070 Tons).	Progress (29,860 Tons).	Wealth of Nations (23,971 Tons).
	s. d.	s. d.	s. d.
Ore-extraction—			
Labour and salaries	8 6·43	7 1·03	5 8·20
Explosives ., ...	0 5·38	0 3·42	0 2·56
Timber	1 5·31	1 1·38	1 0·58
Compressor	0 9·38	0 4·10	0 3·00
Miscellaneous	0 10·01	0 9·39	1 0·59
Hoisting	1 6·24	1 7·59	1 11·79
Transportation	0 6·26	1 2·57	0 7·24
Maintenance	0 11·24	0 11·67	1 6·27
Pumping and bailing	0 4·27	0 1·28	0 0·58
	15 4·52	13 6·43	12 4·81

TREATMENT-COSTS (PER TON MILLED).

—	Blackwater (50,426 Tons).	Progress (31,150 Tons).	Wealth of Nations. (25,470 Tons).
	s. d.	s. d.	s. d.
Ore-transport	0 1·26	..	..
Rock-breaking	0 1·36	0 1·54	0 1·77
Stamp milling	1 4·83	1 7·36	2 4·99
Tube milling	0 3·14	..	..
Concentrating	0 1·59	0 6·24	0 1·43
Quantity collected	(518 tons)	(395 tons)	(150 tons)
Cyaniding	1 2·92	1 0·18	1 3·49
Quantity treated	(28,399 tons)	(17,020 tons)	(16,361 tons)
Retreatment of old tailings ..	..	0 6·61	..
Accumulating slimes	0 0·03	0 0·09	0 0·90
	3 3·13	3 10·02	4 0·58

These costs, together with bullion charges and general expenses, which include insurance, rates, and rents, make up total working-costs as under:—

TOTAL WORKING-COSTS PER TON.

	Blackwater.	Progress.	Wealth of Nations.
	s. d.	s. d.	s. d.
Mining-costs	15 4·98	13 6·08	12 5·42
Treatment-costs	3 3·13	3 10·02	4 0·58
General expenses	2 2·14	1 11·07	1 11·88
Bullion charges	0 9·97	0 7·08	0 8·66
	21 8·22	19 10·25	19 2·54

Working-costs* for 1904—Progress, 17s. 4·64d.; Wealth of Nations, 16s. 4·89d.

The rise in the working-costs in ten years is due chiefly to the increased price of labour and, to a less degree, to that of materials. It should be noted that the enhancing of the costs would have been even more marked but for the reorganization of the methods of working that has taken place in recent years.

* Mines Report, 1905, C.–3, p. 93.

FINANCIAL AND OTHER CONDITIONS.

All the lode-mining hitherto undertaken in the Reefton Subdivision has been on Crown land, for which privilege an annual rental of 7s. 6d. per acre is paid, with, however, a substantial reduction for the first two years. What are known as prospecting licenses cost only 1s. per acre per year, and do not need to be surveyed. The Warden has much discretionary power as to the enforcement of the labour conditions of a lease, and in a general way this power has been exercised with moderation and judgment. The individual alluvial miner's only legal responsibility is the possession of a miner's right, which costs 5s. per year.

Local rates, varying from 3½d. to 4d. in the pound of the capital value of each claim, go to the County Council for the maintenance of roads, &c. Each ounce of gold won from the mines also bears a tax of 3d., which is paid to the Gold-miners' Relief Fund.

In the early days of lode-mining the conditions for the granting of claims were similar to those obtaining in alluvial mining. Thus the claims were small, not exceeding 4½ acres in area. It was soon recognized, however, that more ground was necessary to give a chance of repayment of the investor's heavy expenditure, and the area of the claim was increased to a maximum of 16½ acres. This size of holding was later increased to 30 acres, and still later to 100 acres. Groups of adjacent claims may be held by the same owner, provided the labour conditions are complied with in the aggregate. All the large companies operating in the district hold considerable areas (up to 800 acres) in order to protect themselves against the vagaries of the ore-bodies.

Coal-mining.

Although there is no record of the fact, the prominent coal-outcrops of Murray and Lankey valleys must have been noted by the earliest alluvial diggers. The first coal mined in the district was probably won from the Murray Creek deposits for the Ajax power plant, and other coal-mines were opened as fuel became necessary in connection with lode-mining. The distribution of the patches of coal-bearing strata is very convenient for the various quartz-mines, a fact that has had a most important influence on the development of the district, and the history of many of the coalpits may be inferred from that of the lode-mines they supplied. At this time each gold-mine had its own coal claim, and these in consequence were not developed systematically. The Durham Mine, situated in the basin of Burke Creek, seems to have been the first opened exclusively to satisfy household requirements. This mine appears to have had a very short life, and for many years the domestic supplies were drawn from the mines at Murray, Lankey, and Devil creeks.

During the time of the dredging boom several pits were opened on the seams outcropping at various points near the Buller River from Three-channel Flat to Berlin's. These were entirely dependent upon local requirements, and as the demand ceased when the dredges were shut down they also were abandoned. The Whitecliffs Mine, however, is still worked occasionally. The dredges of the Boatman Creek basin have greatly stimulated production from the two coal-mines situated there, while in another part of the subdivision the coal of Moonlight Creek was attacked to supply fuel to a dredge in that locality. At the present time the Murray Creek and the Burke Creek groups of mines produce the bulk of the coal used in Reefton, the pits at Deep Creek, Merrijigs, and Capleston being worked chiefly in connection with the power requirements of gold-mines and dredges.

So far no attempt has been made to develop the seams of the subdivision in a large way. A little coal is, and has been for many years, railed to Greymouth and Hokitika, where its reputation as a household fuel stands high.

METHODS OF WORKING.

Throughout the Reefton Subdivision the general method of winning coal is by bord-and-pillar workings, the pillars being later removed as far as possible. There is no large systematically worked colliery in the district, and no standard dimensions for bord or pillar are observed, the size of these depending on local conditions. At Murray Creek and at Merrijigs, where the cover of the coal is not great, a considerable tonnage has been won from open workings. Again, where the coal-seams have a very steep dip, as at the now abandoned mines of Three-channel Flat and Rainy Creek, the coal was won by a modification of the long-wall system, the method being devised by quartz-miners accustomed to stoping.

In the early days, before the appointment of an Inspector of Mines, the underground workings of the small coalpits in the neighbourhood of Reefton were very irregular and often dangerous. Thus Mr. G. J. Binns* states, "The system of working, which is noted as 'bord-and-pillar,' by no means as a rule deserves the name, most of the mines being worked on any or no principle, the main object apparently being to get some coal as cheaply as possible, let the roof fall in, and start somewhere else."

Naked lights are used, and fire-damp has been reported on two occasions only, at Murray Creek† and at the Progress Coal-mine.‡ Doubtless the absence of gas is due to the thinness of the cover beneath which the seams have hitherto been worked, and when the seams underlying the gravels of the valley are attacked the usual precautions will need to be taken.

TIMBER INDUSTRY.

In the Mawheraiti valley are three large sawmills—that at Ikamatua owned by the Ikamatua Sawmilling Company, that at Hukarere by Stratford and Blair, and that at Mawheraiti by Perotti Bros. These mills are chiefly concerned with the export trade by way of the port of Greymouth, and Perotti Bros. also supply much of the timber used in Reefton. In the Inangahua valley the only mill in constant operation is that of Lockington Bros., which draws its timber from the Burke Creek flats. A very large proportion of the sawn timber required by the mines is cut by this plant, which in addition satisfies, in part, the demands of the local building trade. De Filippi's mill, situated about a mile from Three-channel Flat, is only intermittently employed. Other small privately owned concerns are placed one near the road-crossing at Landing Creek, one near the railway just south of Larry Creek, and another on the Deep Creek saddle on the road to Big River. In addition the Progress, Blackwater, and Big River mines have small plants, while, near Barrytown, White and McKay cut planking for flumes and tables at their own mill.

A considerable number of men are engaged in contract work, supplying rough mining-timber to the quartz-mines. In the forests close to the long-worked mines suitable trees are now very scarce. Thus the Crushington mines draw their supplies from the flats ten miles up the Inangahua, while the Progress Mines obtain the necessary material from the lower valley of Devil Creek, at a constantly increasing cost. The Big River Mine is situated on the high plateau country where the bush is poor, and, as wood was burnt under the boilers for many years, the upper valley of the Big River is now practically denuded of accessible trees; and this company was forced to construct an expensive adit from the Deep Creek basin, where crushed coal is mined and a limited supply of timber exists. The Blackwater Mine is in a much more favourable position as far as timber is concerned than any other large quartz-mine. Sleeper-cutting has for many

* H.–18, 1880, p. 13. † Mines Report, 1888, C.–4, p. 5. ‡ Mines Report, 1892, C.–3B, p. 7.

years provided employment for a considerable number of men, but this branch of the timber industry is now declining, and practically all the existing silver-pine bush has already been worked.

The principal timber-tree is the rimu or red-pine, and this is far more abundant in the Mawheraiti valley than in that of the Inangahua. Very large amounts of this timber are still available in the subdivision, but the readily accessible supplies growing on the flood-plains and terraces of the Grey valley are rapidly approaching exhaustion, and will probably be cut out in two or three years. Other even more valuable timber-trees are the totara and black-pine, but these are not at all abundant. The white-pine is fairly common on the low swampy flats where the land is rich, but is now practically cut out. The beech (*Fagus fusca*)—known locally as the black or brown birch—is very common, generally occupying soil too poor to be tolerated by any of the pines. It is extremely abundant in the Inangahua valley; and much of the bush on the Reefton hills is composed exclusively of this species, which also forms the forest of the lower flanks of the mountains. The sawmiller gets a better price for lumber cut from this tree than from the red-pine; but the logs are so full of shakes and flaws, and boards cut from sound timber are so liable to split when nailed, that it is rarely used save as large timber. In the mines, on account of its strength and durability, it is preferred to all other woods. The silver-pine, of which the habitat is the swampy terraces and plateaux, is eagerly sought by sleeper-cutters. To avoid waste the logs are usually sawn, but the smaller sticks are hewn, the excellent working-qualities of the timber making this an easy matter. It should be noted that trees growing on very swampy land are much more likely to exhibit " ring shakes "—that is, shakes coincident with the rings of growth—than those standing on drier ground. On the mountain-flanks there is a considerable amount of totara (*Podocarpus Hallii*), which, though neither so large nor so durable as the true totara (*Podocarpus totara*), may yet be found of great value.

Other Primary Industries.

The other primary industries include agriculture, dairying, grazing, flax-milling (*Phormium tenax*), lime-burning, and brickmaking. The last two, however, must be considered in the nature more of experiments than of permanent industries. In regard to flax-milling, the only plant in operation in the area examined is situated at Barrytown, where great areas of flax-covered swamp exist. New Zealand flax is also cut at several other places, and railed to mills beyond the boundary of the subdivision.

The land up to the present found worth cultivation does not form a large proportion of the whole area of the district. The rainfall is so abundant that only those lands that are readily drained—that is, those on hill-slopes or on flats of which the subsoil is permeable gravel—can be utilized. In regard to the former, only the gentler slopes can retain sufficient soil for more than a most scanty growth of grass, while the latter is confined to the flood-plains and lower terraces of the larger streams, since the higher terraces are underlain by an impervious hard pan. Extensive areas in the Grey, Mawheraiti, and Inangahua valleys are either devoid of bush or covered by a readily destroyed growth of scrub. These pakihis, however, are still largely in their natural condition, and no commercially practical method of dewatering them has yet been devised.

The largest patch of arable land is at Totara Flat, but considerable areas occur along the courses of all the rivers. The principal products grown are oats and root crops, but the methods in use are, generally speaking, decidedly primitive. Of late years dairying has come into prominence, and a butter-factory that draws its supplies from the Grey and Inangahua valleys has been in operation at Cronadun for about ten years. The settlers at Brighton send their cream to a factory formerly at Charleston, but lately shifted to Westport, while those at Barrytown in the spring of 1914 were taking steps to establish another at that township. The climate of the inland valley is decidedly more severe than that of the successful dairying districts of the North Island; and, until more attention is devoted to providing nutritious winter feed, results comparable with those of other parts of New Zealand cannot possibly be achieved. Cattle-raising is one of the chief branches of farming followed at the present time, while sheep-farming is but little practised. At no time in the history of the West Coast has the demand for foodstuffs been satisfied by the local supply, and there appears to be little hope of this condition ever being reached.

CHAPTER III.

PHYSIOGRAPHY.

GENERAL FEATURES.

The Reefton Subdivision presents physiographical features of great variety and interest. A rugged mountain-chain with peaks rising well over 5,000 ft. bounds the district to the eastward, while another great range traverses its western portion meridionally. Between lies a wide structural valley, on the floor of which the mountain-streams unite to form rivers which flow north and south to join the two largest drainage-systems of the West Coast. Terraces, sometimes extensive enough to earn the local name of plains, occupy a great part of the valley. Near its main water-parting the soft strata that form its floor have been sculptured by subaerial denudation into low broken hills. Another area of low but decidedly broken country lies between the western mountains and the sea. Along the shore-line for miles the waves bank up sand and gravel, forming the beaches and littoral swamps of a narrow interrupted coastal plain. At other places the sea is actively cutting back the land, and there the coast is bordered by high vertical walls or steep rugged slopes, according to the nature of the rocks.

MOUNTAINS.

The Paparoa Mountains, which occupy a large area in the western portion of the subdivision, extend north and south beyond the limits of the area examined. Longitudinal valleys divide the mountains into roughly parallel ridges that run in a general north-north-east direction. Although these ridges are not placed in exact alignment, it is possible to group them into three more or less coherent chains. The western chain, terminating at its northern end in the Buckland Peaks, is continued beyond the Waitakere as the Lochnagar Range that stretches south beyond the limits of the subdivision. Mount Faraday (4,800 ft.) belongs to the northern section of the range; but in mounts Cavendish, Priestley (4,660 ft.), Dewar, Ramsay (4,630 ft.), and Lodge (4,760 ft.) the Lochnagar Range has heights of a similar order. Southward the peaks are lower, as Mount Pecksniff (4,250 ft.), The White Knight, Mount Hawera (3,890 ft.), Crœsus Knob (3,940 ft.), and Mount Leitch (3,780 ft.). The central chain is divided from the western in the north by the long valley of the Ohikanui, and in the south by those of the Gordon and Upper Freeth. Its highest peak is Mount Uriah (4,925 ft.), while farther south are Mount Micawber (4,835 ft.), The Pinnacle (4,620 ft.), and, across the gorge of the Gordon, Mount Johnston (3,950 ft.).

The eastern chain, separated from the central by the valleys of the Blackwater, Te Wharau, and Otututu rivers, is itself divided imperfectly by the valley of the

Whitefoord and a depression crossing the heads of the Maimai and Giles streams. Notable peaks are mounts Stevenson (4,585 ft.), Epping (4,700 ft.), Wise (4,195 ft.), McHardy (4,196 ft.), and Raoulia (4,400 ft.).

The Victoria and Brunner mountains form the eastern boundary of the subdivision. Like the Paparoa Range, these highlands may be divided into parallel chains, and this is so obviously the case that the Brunner Range is popularly separated from the main mass of the mountains. From the lowlands this range has the appearance of a long continuous ridge stretching from the Buller River south as far as Larry Creek. Prominent heights are Boundary Peak (4,040 ft.*), Mount Curtis (4,600 ft.), Mount Wynn (4,635 ft.), Bourke's Rocks (4,282 ft.), and, south of Larry Creek, Conical Hill (3,430 ft.).

Separated from the Brunner Range by the valleys of Little Deepdale, Revell, and Drysdale streams is a range which may be called the Kirwan Range, from Mount Kirwan (4,247 ft.), its best-known peak. Across Bateman Creek is Trigonometrical Station J (4,081 ft.), and beyond the head of Larry Creek are mounts Ossa and Pelion (4,927 ft.).

Victoria Range proper lies to the eastward of the subsidiary ranges just described, and enters only the south-eastern corner of the subdivision. The southern continuation of this chain across the Grey River is known as the Werner Range. Notable peaks within the subdivision are mounts Albert (5,069 ft.), Ross (4,974 ft.), and Gore (4,873 ft.). The highest point in the group of ranges is Trigonometrical Station U (5,671 ft.), six miles east of Mount Albert and four miles without the area examined.

PLATEAUX AND HILLS.

Southward and in direct continuation with the Brunner and Kirwan ranges is an area of country of decidedly lower elevation, which stretches as far as the Big Grey. A distant aspect produces the impression that this country consists of rolling downs with a gentle rise to the eastward, but a closer acquaintance proves the apparently simple maturely sculptured surface to be exceedingly broken. The major streams flow at grade hundreds of feet below the general level of the plateau, while the minor streams are deeply incised. In this report this dissected upland will be termed the Reefton plateau or the Reefton hills.

Another area of moderate elevation and with a surface similarly sculptured occurs in the north-eastern portion of the subdivision between the Buller and the Orikaka. An extension of this area lies south of the Buller, occupying the strip of land between that river and the Inangahua. This upland country is the southern end of a much larger area of corresponding elevation, within which lie the major portions of the Ngakawau and Orikaka basins.

The Brighton plateau, which is in part a true plateau, lies between the Paparoa Mountains and the sea. Near the coast the rocks consist of gently dipping resistant limestones, and the surface of these rocks from a distant aspect is apparently simple, but is actually exceedingly broken. Nearer the mountains the rocks are weak sandstones, and a much maturer stage of erosion has been reached, the uplands in this direction grading into a longitudinal depression which, between Bullock and Dilemma creeks, is interrupted by a comparatively narrow cliff-bordered ridge connecting the Brighton plateau with the foothills of the mountains. Northward the plateau extends beyond the limits of the subdivision, and southward of the Punakaiki it merges into the above-mentioned depression.

* The trigonometrical station on Boundary Peak is situated at a height of 3,995 ft.

Plate III.—Gorge between Black's Point (Foreground) and Reefton (Middle Distance), incised 600 ft. to 800 ft. below the General Level of the Reefton Plateau.

Face p. 36.]

RIVERS.

The watercourses of the Reefton Subdivision may be divided into three natural groups, consisting of the streams draining into (*a*) the Tasman Sea directly, (*b*) the Buller River, (*c*) the Grey River.

The Coastal System.

The western slopes of the Paparoas are dewatered by five considerable streams, of which four have their basins within or almost entirely within the subdivision. The most southerly, the Ten-mile (or Waianiwhaniwha) Stream,* flows south-south-west in a somewhat wide meridional valley for a distance of three miles, then turning to the westward it reaches the sea through a deep gorge, of which the lower portion follows closely the southern boundary of the area here dealt with. Numerous small streams draining the sea-front of the most western ridge of the Paparoa Range flow to the sea north of the Ten-mile before the next large stream is reached. Of these, Baker (or Maukurunui), Fagin, Granite, Canoe (or Okiwi), and Lawson (or Waiwhero) creeks are the most important, and maintain semi-permanent outlets through the storm beaches of the shore-line. The Punakaiki (or Deadman) Stream, which is slightly larger than the Ten-mile, after a most tortuous upper course in its mountain-valley, plunges in a continuous cataract through a short gorge, and then meanders over a flood-plain set between vertical limestone walls from 400 ft. to 500 ft. high. The Porarari (or Punangahaire), in its turn slightly larger than the Punakaiki, reaches the sea about a mile north of the latter. This stream rises in a deep V-shaped valley which opens out when the Brighton plateau is reached. For miles the river flows quietly in entrenched meanders, when it is joined by Cave Creek, an affluent of nearly equal size. The combined waters immediately enter the lower gorge, and flow at grade between towering walls for over two miles. Cave Creek issues a full-fledged stream from a low cavern in calcareous strata. Its tortuous course is entrenched 50 ft. to 100 ft. below a wide gravel-covered depression that stretches northward from the Porarari, parallel with the base of the mountains. The upper valley of Bullock Creek is very similar to that of the Porarari, being a narrow trench cut in solid rock and cumbered with huge rocks. When softer strata are reached the valley widens, and the stream flows quietly towards a deep notch cut in the hills which bar its way to the sea. No sooner, however, is the stream within the walls of the cañon than the current ceases and the water soaks through the gravelly bed to fissures in the limestone, to reappear as Cave Creek. The dry flood-channel continues down the cañon cut by the stream in former times, and one distributary leads to a timber-blocked sinkhole at the base of a limestone cliff, while another may be followed to a narrow swamp drained by a small stream known also as Bullock Creek (or the Omonehu), trickling to the sea through a gorge bounded by stupendous vertical cliffs. This rill, having cut a narrow gash in the soft sandstone that lies beneath the gravels of the valley-floor, flows over solid rock into the lagoon at its mouth. Two moderate-sized torrents, cut deep in the western flank of the Paparoa Range, unite to form the Fox (or Potikohua) River, which flows through a narrow flood-plain for two miles before entering the profound cañon of its lower course. Dilemma Creek, a stream similar in size and history, joins it 20 chains below the cañon's upper entrance. Two other affluents of considerable size add their waters, one from either side, issuing as springs amid the jumbled talus blocks that mask

* Haast, in his "Report of a Topographical and Geological Exploration of the Western District of the Nelson Province, New Zealand," 1861, p. 46, refers to this stream as the Waianiwhenua, while Canoe Creek is called the Kokiwi. In the same report (p. 47) he states that the name Punakaiki is applied to the rocky headlands just south of the river which is here called by that name, but which he terms the Porarari, a designation now given to the stream he calls the Punangahaire.

the base of the unbroken limestone cliffs. Near the sea the walls retreat a little, and the river anastomoses over a bed of fine shingle. The Four-mile (or Tiropahi) Stream and the much larger Nile (or Waitakere) River rise within the district, but cross its northern boundary into the Buller-Mokihinui Subdivision.

The Buller System.

The Buller (or Kawatiri), one of the largest rivers in New Zealand, enters the Reefton Subdivision at its north-east corner immediately after traversing the rock-bound Lyell Gorge, by which it escapes through Victoria Range. The river flows with rapid current entrenched 30 ft. to 40 ft. below an old valley-floor. After receiving the waters of the Inangahua its course is through a limestone gorge—the Whitecliffs Gorge—below which lies the wide Rocklands Flat, cut, when the river was at a higher level, from the soft claystone that underlies the limestone. Here the Orikaka comes in from the north, and the river, leaving the area here described, enters its famous lower gorge. Small modern flood-plains exist at Rocklands and Three-channel Flat, but these are quite inconsiderable. Throughout its course within the subdivision the Buller is obviously entrenched on the floor of an older and more mature valley.

The Orikaka (or Mackley) River has most of its basin without the subdivision. Of the three miles of its course within, over two are through a deep gorge cut in hard igneous rock hundreds of feet below the level of the surrounding uplands, while its lower portion is entrenched 30 ft. or more in the Rocklands Flat. Welshman Creek, which reproduces in miniature the basin of the Orikaka, drains part of the same area, and its gorgy lower course contrasts strikingly with the wide mature valleys of its headwaters.

The Inangahua* River, one of largest tributaries of the Buller, has almost the whole of its basin within the subdivision. It rises in the eastern portion of Victoria Range, and flows first southward and then westward in a well-opened mature mountain-valley. The absence of interlocking spurs, the hanging-valleys and great vertical cliffs, as well as the vast piles of moraine, bespeak the presence of a former great glacier. On leaving the mountains the stream turns northward and flows along their base, receiving a large tributary in Rough (or Tobin) Creek. Changing its character, the valley loses its glacial features, and assumes those indicative of purely fluviatile origin. The stream flows through valley lowlands about a mile wide, set between steep youthful-looking valley-walls. Down-stream the flood-plain narrows, and four miles above Reefton almost disappears, the river entering a typical cañon—the Black's Point Gorge. At Reefton it debouches on the plain, and, embarrassed by vast quantities of waste, swings in braided channels first north-west then north-east, and finally nearly north to its junction at grade with the Buller twenty miles away. In this portion of its course it receives many tributaries, of which the chief are the Waitahu, Larry, and Te Wharau rivers. Other notable affluents are Burke, Boatman, Landing, Coal, Brown, and Rough creeks from the eastern mountains, and Giles, Fletcher, and McMurray creeks from the Paparoa Range. Near the junction of Landing Creek the river becomes entrenched below its flood-plain, and exposes the soft rocks of the valley-floor along vertical banks, between which it is actively engaged in cutting a new flood-plain. For a short distance below its confluence with the Buller the brown Inangahua water may be distinguished from the paler clearer water of the larger stream.

The Waitahu, a river at their junction fully as large as the Inangahua, is formed by the union of the drainage from three once glaciated valleys which lie in great

* The alternative name "Thackeray" is given on an old map of the Ahaura meridional circuit, published in 1879.

part without the subdivision. Its middle course through the Reefton hills is similar to that of the Inangahua, which stream it joins five miles after leaving the uplands and four miles from Reefton.

Larry Creek, or the Awarau (or Colin*) River, is somewhat smaller than the Waitahu, and, like it, is formed by the union of several streams. A large, formerly glaciated, valley lies between the Brunner and Kirwan ranges, and drains southward into the main stream, which cuts right across the Kirwan Range and deeply into Victoria Range. The united streams plunge through a profound rock-bound gorge. Hundreds of feet above the torrent are gravel-strewn rock platforms, the remnants of an ancient valley-floor which may be traced north and south beyond the forks at an ever-lessening height above the river-level, and finally merges into the present upper valley. On leaving the gorge the river flows on a narrow flood-plain between high terraces, and joins the Inangahua at grade.

The Te Wharau (or Stony) River flows in a wide mature mountain-valley, and receives the Kynnersley and other streams from similar valleys before turning abruptly eastward and plunging in a continuous cataract through a gorge cut in ancient moraine and solid granite. Its lower course through the gravels of the Inangahua valley is similar to that of the Larry River, opposite the mouth of which it joins its parent stream.

These major tributaries of the Inangahua—the Waitahu, Larry, and Te Wharau rivers—have this in common: that each cuts through one range, and collects the drainage from the depression between it and the next parallel ridge. In fact, these streams must be considered to have carved the ranges by their erosive power. Thus the Montgomerie River (the north branch of the Waitahu) has its course between the Victoria and Kirwan ranges, while the main stream cuts through the southern end of the latter range. The Larry River crosses the end of the Brunner Range, and its branches north and south separate that range from the next ridge, which is in turn deeply penetrated by the main headwater stream. The Te Wharau has a similar course, and illustrates this peculiarity even better than the Waitahu and Larry rivers.

The numerous minor streams that drain into the upper Inangahua are mountain-torrents either with great waterfalls or deep impassable gorges in their lower courses, while their upper valleys are comparatively open and mature. In the middle course of the Inangahua the small tributaries on the right bank—McConnochie, Garvey, Lankey, and Murray creeks—have gorgy lower courses, but the valleys open out near their sources. On the left-hand or southern side, however, each little valley is deeply incised and youthful to its very source. There is one exception: Golden Lead Creek, a large branch—in fact, the main headwater—of Deep Creek, has a gorgy lower course which merges into a mature upper valley. In the lower Inangahua valley the eastern minor tributaries fall into two groups—those that flow across the Inangahua lowlands with channels anastomosing through flood-plains of greater or less extent, and those of which the lower courses are entrenched beneath the main valley-floor. To the first group belong Burke, Boatman, and Landing creeks. Burke Creek is formed by the union, on a swampy flat, of several small streams with immature valleys which drain from the uplands between the Inangahua and Waitahu rivers. Boatman Creek is decidedly larger, and drains the Reefton hills between the Waitahu and Larry rivers. Its main source is in a mature valley, but the stream soon plunges into a gorge, from which it does not emerge until the soft strata of the lowlands are reached. Both the main sources of Landing Creek are similar, and even the little St. Helena Creek has a mature upper valley. The second group of streams—Coal, Brown, and Rough creeks,

* An alternative name given to this stream in a map accompanying the report of Mr. Warden Broad, 1873, H.-7, p. 15.

with which may be included Dee, Ram, and Flaxbush creeks, which drain to the Buller direct—have beds entrenched below their ancient flood-plains across the Inangahua lowlands. All deeply incise the mountains, but have their sources in mature valleys high on the flanks of the Brunner Range.

The lower Inangahua receives few tributaries from the Paparoas; the nearly parallel meridional valleys of the Te Wharau and the Blackwater* capture all the drainage except that from the eastern face of the range. McMurray and Fletcher creeks are small streams formed each by the union on the lowlands of several brooks deeply incised in the southern portion of the Orikaka uplands (see page 36). Giles Creek is a much larger stream, which draws its waters from a portion of the mountains just south of the longitudinal valley of the Te Wharau. Its upper valley is mature, but the stream passes through a long gorge before reaching the lowlands, along the edge of which, entrenched in a narrow flood-plain, it makes its way to the Inangahua.

The Grey System.

In many respects the Grey River resembles the Buller; it has its source in the main Alpine chain, and, passing through a deep gorge between Victoria Range and its southern continuation (the Werner Range), flows for a few miles in a wide structural valley (see page 63), finally escaping to the sea through the extreme southern part of the Paparoa Range by the Brunner Gorge. After leaving the gorge through Victoria Range—the Gentle Annie Gorge—the Big Grey (or Pohaturoa, as it is here called) is joined by the Alexander, a considerable stream draining the mountains south of the Inangahua, and by the Clarke coming from the Werner Range. That portion of the river within the subdivision has a westerly and north-westerly course to the confluence of the Little Grey (or Mawheraiti) River, which may be considered the counterpart of the Inangahua. The united waters, now known as the Grey (or Mawheranui) River, turn south-westward, and, after a relatively straight course of seven miles, enter the north-east corner of the Greymouth Subdivision. While within the Reefton Subdivision the river is characterized by a flood-plain from 50 chains to 100 chains wide, set between high wide terraces. The bed itself consists of wide gravel beaches, through which the river flows in braided channels. Besides the Mawheraiti, it receives as major tributaries from the Paparoa Range the Otututu and Freeth rivers and Moonlight and Blackball creeks.

The Mawheraiti (or Little Grey) River has its source in the low hills that border the left bank of the Inangahua, and flows in a narrow flood-plain cut deep in the eastern edge of wide swampy terraces. From the Paparoas it receives tribute by means of the Maimai, Casolis, Whitefoord, Rough-and-Tumble, and Burton creeks. Casolis is formed by the union of rills from the very face of the range, but the others cut more or less deeply into the mountains, and have wide mature upper valleys which merge into wild gorges before the lowlands are reached. From the east, Slab Hut and Antonio creeks and the Blackwater and Snowy rivers drain part of the Reefton hills. All these streams have wide mature valleys towards their heads, but reach the lowlands through long narrow sinuous gorges. In the case of the larger streams, such as the Big River (a branch of the Blackwater) and the Snowy, very little of the ancient valley-floors remain, but the heads of Slab Hut and Sawyer creeks are admirable examples of mature valleys, in startling contrast with the youth of their lower courses.

The Otututu (or Rough) River, which joins the Grey close to Little Grey Junction, has its source among the western ridges of the Paparoa Mountains. The great longi-

* This stream flows to the Buller, and must not be confounded with the Blackwater of the Grey valley.

tudinal valleys of the main stream and the Gordon are wide, U-shaped, and choked with moraine. Below their junction the valley narrows, and finally becomes a typical fluvial gorge. Mirfin Creek, which joins it just after its escape from the range, has a mature upper valley merging into a narrow gorge. Across the lowlands the river anastomoses between high terraces.

The Big* (or Freeth) River has a wide upper valley, into which open several hanging-valleys. It escapes from the mountains by way of a deep gorge which is continued through the gravel terraces and underlying rock of the lowlands. Large branches are Saxton and Slaty creeks, which join it in the lowlands. The Moonlight Creek valley does not appear ever to have been glaciated. Nevertheless, the old upper valley was wide and mature, and in its floor the Moonlight and Garden Gully creeks are now deeply incised. The Roaring Meg, which joins the Moonlight on the district boundary, has a mature upper valley, from which it escapes in a continuous cataract by a most difficult gorge. One other stream deserves mention, the Blackball, of which the upper part is included in the subdivision. As in the case of the Moonlight, entrenching of the upper valley has nearly obliterated all traces of an older mature valley.

THE LOWLANDS.

The largest area of what may be designated lowland within the Reefton Subdivision is constituted by the great depression that lies between the eastern mountains and the Paparoa Range, and stretches meridionally from one end of the subdivision to the other. This hollow, which is termed the Grey-Inangahua depression or trough, may be considered to commence as the narrow valley of New Creek, and to continue as the Buller valley as far as Inangahua Junction. At this point it is at least four miles wide; at the junction of Larry Creek, five miles; at Reefton, seven miles; and at Hukarere, ten miles. South of the Big Grey the Reefton uplands disappear beneath gravels, and the depression widens greatly and becomes finally the ancient coastal plain of Westland.† On the western edge of the depression the separation from the hills is easy and the line of separation simple, and this also applies to the northern portion of the eastern edge; but in the valley of the Mawheraiti the eastern boundary is imbricated and more or less arbitrary.

The floor of this depression is almost entirely covered with gravels of various ages. The oldest of these have been carved into low hills, but the greater part of the area is divided into steps by great terraces. A large area sculptured into hills separates the watersheds of the Inangahua and Mawheraiti, and stretches across the depression, grading into the Reefton hills to the eastward and extending along the left bank the Mawheraiti as far south as the Blackwater River. Still farther south beyond the Big Grey similar hills occupy an area between that river and the Ahaura.

Of a height but little inferior to the hill-crests in their vicinity are remnants of ancient flood-plains still retaining their flat surfaces. These high terraces are well seen between the tributaries of the Inangahua from Reefton to the Buller, and again as Welshman pakihi, north of the Buller opposite Three-channel Flat. In the Mawheraiti valley along the western side, wide stretches of pakihi plain rise in gradual steps from the terrace-edge that overlooks the arterial stream, to a height suggesting a correlation with the highest terraces of the Inangahua valley. These may be traced along the eastern flank of the Paparoa Range as far as Shetland Terrace, overlooking the Moonlight. On the eastern side of the Grey valley a remnant is preserved near the point

* The writer, to avoid confusion with the main branch of the Blackwater, which is also called the Big River, has given this stream the alternative name of Freeth, after Isaac Freeth, the first settler on the Ohinetakitaki Plain, which lies opposite the mouth of this river.

† Bull. No. 13, 1911, pp. 33, 34.

where Slab Hut Creek breaks from the hills, and probably also the high terrace between the Blackwater and Snowy rivers belongs here. Southward the Grey has destroyed all trace of high-level terraces, so far as the area here described is concerned.

Between the remnants of high-level terraces just described and the recent flood-plains of the rivers is a great series of terraces, which in the Inangahua valley are distinguishable from both the high terraces and the flood-plains. In the Grey valley, however, descent from the high-level terrace is generally gradual by many steps, although the flood-plain boundary is well marked everywhere.

The lowlands of the coastal region—that is, the area between the highlands and the sea—are not of great extent. A considerable depression lies at the foot of the Paparoa Mountains, and separates them from the Brighton plateau. From the Buller-Mokihinui Subdivision this depression extends to Dilemma Creek, south of which rises a cliff-edged ridge. Beyond this ridge the lowlands are continued past the Punakaiki, south of which they taper off to nothing near Barrytown, between the mountains and the coastal plain that backs the Seventeen-mile Beach. This coastal plain has a length of nearly ten miles and an average breadth of a mile. It rises gradually from the beach to a height of nearly 200 ft. at Barrytown. Other coastal plains occur near Brighton, and again between the Ten-mile and Fourteen-mile bluffs. These are so narrow, however, as to deserve the name of "raised beach" rather than that of "coastal plain."

THE COAST.

The shore-line of the Reefton Subdivision has a length of nearly twenty-seven miles, and presents features of a most varied nature. The bold gneiss-granite cliffs of Tuhinu Hill that form the shore-line in the southern portion of the Buller-Mokihinui Subdivision give place to wild rocky points with intervening sandy coves. At St. Kilda commences a long stretch of sandy beach backed by a narrow coastal plain scarcely 5 chains wide, which sweeps in a long curve to the Fox River, south of which it turns more to the westward and tapers off against vertical cliffs about 50 ft. in height that terminate in an unimportant cape. A small island, Seal Island, and many stacks occur at this place, and, in conjunction with the cape, afford some protection from south-westerly winds and swell to the precarious anchorage of Woodpecker Bay. The cliffs are continued round a headland, known as Kaipataki; and soon sandy beach appears, and gradually widens southward as the Maungahura cliffs decrease in height and merge into low hills. Granitic rocks appear again at Motukutuku Point, and for two miles the shore is formed of rocky points with intervening beaches backed by precipitous cliffs. This portion of the coast, known as Irimahuwheri, gives place to a narrow wave-swept beach, from which rises, sheer for more than 1,000 ft., the great cliff of Te Miko. All trace of fringing beach disappears as the cliffs turn westward to Perpendicular Point; and for more than a mile, until Pakihiroa Beach is reached, vertical cliffs about 300 ft. in height form the shore. Pakihiroa Beach is more than a mile long, and at low tide is about 15 chains wide. At the mouth of the Porarari is a small raised beach or delta, backed, as is the rest of the beach, by great limestone cliffs, which at Cave Point project into the sea. Beyond this another small gravel beach appears, which reaches to Razorback (or Okoriko) Point. This is the last appearance of the limestone on the coast, and a sand-and-gravel beach—the Seventeen-mile Beach—more than ten miles in length, fringing a low coastal plain, now forms the shore-line. The southerly drift has assorted the waste on this beach so as to show a fineness increasing from south to north. The coastal plain feathers out at Maukurunui Bluff; and for about three miles from Baker Creek to the Fourteen-mile Bluff the sea is faced by bold cliffs and steep spurs, with occasional sandy beaches. From the Fourteen-mile Bluff a very narrow coastal plain backed by steep hills forms the shore-line for nearly two miles, when sea-cliffs appear and continue to the southern boundary of the subdivision.

The most striking feature of the sea-front as distinct from the actual shore-line is the great cliff that, sweeping in smooth curves from the northern boundary to the Punakaiki River, occasionally reaches the shore, as at Te Miko and Pakihiroa Beach. The remainder of the coast north of the Punakaiki is carved out of the rock platform from which the cliff rises. It is obvious that this feature is an ancient sea-cliff that marks a considerable stillstand, during which the sea cut back the land and formed a mature simple coast. Since elevation left this ancient strand-line high and dry the old wave-cut platform has been attacked by the sea. The present irregular youthful coast-line is due to the heterogeneous nature of the rock platform, for the weak rocks have been cut back, leaving the resistant ones standing out as bold headlands.

That the elevation took place in several stages, with intervals of rest, is proved by the existence of rock terraces, veneered with beach-gravels, at various heights along the sea-front. In former years these gravels were of great economic importance, in that they yielded large quantities of detrital gold. In consequence of this their distribution and height above sea-level are well known, and it is possible to give a more adequate account of the recent elevations than would otherwise be the case. The most ancient of these strand-lines is that marked by a series of beach-gravels from 400 ft. to 500 ft. above sea-level, which may be correlated with those of the "500 ft. terrace" of the Westport–Charleston district.* Isolated patches occur at many points from Barrytown as far north as the Punakaiki, and again from Te Miko cliff to the Fox River. A much more continuous line of beach-gravels and rock benches marks a lower strand-line, which in this report will be termed the "200 ft. strand-line"; this corresponds with the "250 ft. terrace" farther north. It stretches without a break from Barrytown to north of the Punakaiki, occurs inland from Perpendicular Point, and nearly continuously from Hatter Bay to beyond the northern boundary of the subdivision. Another strand-line, more recent still, but by no means so well marked, may be traced by gravels and rock-cut platforms lying from 60 ft. to 100 ft. above sea-level; this may be termed the "80 ft. strand-line," and is prominent near Seal Island, Perpendicular, Cave, and Okoriko points. The low narrow coastal plains at Brighton and north of the Ten-mile Bluff, and, in fact, at the head of every cove along the shore, represent an elevation of from 10 ft. to 15 ft. within very recent times. Other features due to this elevation are the rock-cut limestone platform at the mouth of Limestone Creek and the sea-cave known as Te Ana-o-Matuku, south of the Fox River. In respect to the coastal plain at Barrytown there is little doubt but that its formation commenced at the time of the 200 ft. strand-line, and that its area has increased as each later elevation has caused the hard rock of Okoriko Point to project farther westward. There are several well-marked beach-lines on its gently sloping surface, each with its old storm beach damming back a narrow swamp that retreats from the sea as it is followed northward at the rate of about 10 chains per mile. It is thus evident that all the pauses in elevation have not been enumerated. When the draining of the swamps and the clearing of the bush have completely exposed the profile of the sea-front, the physiographer will have a better opportunity of adequately studying this interesting example of a rising shore-line.

TARNS, LAGOONS, SWAMPS, SINKHOLES, ETC.

No sheet of water worthy of the name of lake exists within the subdivision, what is known as Lake Rahui, in the Inangahua Survey District, being little better than a

* Bartrum, J. A.: "The Geological History of the Westport–Charleston High-level Terraces." Trans., vol. xlvi, 1914, p. 255.

swamp. Portions of its surface are free of flax and raupo, but its depth can at no place be more than a few feet. From the shape of the lake and from the nature of its surroundings there is no doubt but that it is the remnant of a once more extensive ox-bow lake formed by the Buller when that river flowed at a higher level.

Among the mountains, especially in Victoria Range, glacial rock-basins at the foot of precipitous corries are numerous. These deserve no special mention except that all occur above the present timber-line. Small ponds, at most 20 ft. across and 4 ft. deep, are common on the fell-fields of the mountains. These are always on an exposed place near a ridge, and are confined to granite and gneissic areas. It is suggested that they owe their existence to the fierce whirlwinds frequent in the high country, against the excavating-power of which the loose grit, residual to the frosts, offers a feeble resistance. Most of these have on their edges a spongy cushion of ingrowing moss, while numerous patches of similar vegetation mark the sites of former ponds.

There is a tendency for all the streams flowing to the sea to form lagoons or to have impermanent mouths. Thus the Fox, the largest river, has a small tidal lagoon, while the mouths of the Porarari and Punakaiki, according to old maps, are inconstant. Waiwhero Creek forms a long narrow lagoon, which doubtless also changes its outlet, but the lagoon of Canoe Creek is at present quite small.

Three artificial lagoons of considerable size have been formed by hydraulic-elevating operations on the coastal plain at Barrytown, while irregular areas of standing water have been created by paddock-dredging on the courses of Boatman, Slab Hut, Antonio, Blackwater, Duffers, and Shellback creeks.

In the limestone area of the Brighton hills, especially in the valley of Bullock Creek, sinkholes are numerous. Many of these are dry or filled with swamp, but a few of the more recent near the stream contain standing water.

The swamps of the area are of two main types—littoral swamps and terrace swamps. The former are extensively developed on the coastal plain at Barrytown, where they have great extension parallel with the shore-line, and are in places traversed by forest ridges with a similar alignment. Swamps on terraces are very extensive. In the coastal region large semi-swampy pakihis occur north of the Fox, between the Paparoa Range and the Brighton plateau. These are a continuation of the Charleston pakihis, and have a similar origin. A peculiar swamp, which may possibly represent a large infilled sinkhole, occurs north of Bullock Creek, close to the point where this stream disappears. In the Grey-Inangahua valley all the high-level terraces are swampy, and many of them are devoid of forest growth. The subsoil of these swamps usually consists of a light-coloured silt overlying tight gravel, which is often cemented with iron oxide. Perhaps the most remarkable of these swamps are those on the low terraces north and south of Landing Creek.

SPRINGS.

Mineral springs are but feebly represented in the subdivision. The smell of sulphuretted hydrogen was detected in the upper valleys of the Waitakere and Fox rivers, and this is probably due to hepatic waters arising along some great fracture, but in neither case was such a spring discovered. Chalybeate springs in the lode-bearing country near Reefton and Moonlight are frequent, and every trickle seeping from the recent marine gravels and sands of the coastal district carries iron in solution.

Fresh-water springs, obviously dependent for their supply on surface streams, occur frequently in the limestone areas of the subdivision. The most notable example is furnished by Bullock Creek, which sinks into the ground and reappears a mile to the southward as Cave Creek. Other prominent springs are seen in the cañon of the Fox, which receives large tributaries from beneath the talus of unbroken cliffs. Dilemma Creek also in its gorge has a very variable volume, due to the existence of underground channels, of which some discharge into the Fox River and some back again to its own bed. On the road through the Buller Gorge a fair-sized stream cascades from a cleft in the face of a cliff of calcareous sandstone just above Rocklands Flat. Fletcher Creek, a small branch of the Inangahua, has two channels, the underground one being used in times of normal flow, while the other serves as an overflow during floods. A noticeable feature of the beds of streams that issue from caves is the absence of all the usual traces left by floods: in fact, there are no floods in these streams, the underground channels being sufficient only for normal discharge. Thus the stream-beds are narrow, and just large enough to contain the usual volume of water. No uprooted trees cumber the channel, while vegetation grows right to the water's edge and closely overhangs the stream, and all the boulders projecting above the water are entirely clothed with moss.

CAVES.

The caves of the subdivision may be divided into two groups, according to their manner of formation. The thick beds of flat-lying or gently inclined limestone occurring in the coastal district are peculiarly favourable to the formation of caves by running water. With the exception of the underground channels at present occupied by streams, the longest cave seen by the writer occurs in the gorge of the Fox River, and is evidently a former channel of Cave Creek north. It lies about 200 ft. above the level of the river, and may be penetrated for about 8 chains. In form it is a narrow tunnel occasionally opening out into small chambers. Numerous other similar caves must exist in this region of sinkholes and disappearing streams. Another area of horizontally disposed limestone occurs in the Inangahua Survey District, and in this locality likewise caves are numerous. Caves also occur in connection with the Devonian limestone of Lankey Creek, but here the limestone-beds are broken and highly inclined, conditions unfavourable for the formation of extensive caves. In this place also the alcoves developed in the massive limestone at the upper end of the gorge of the Fox River and that of Dilemma Creek deserve mention. The largest, known as "the Ballroom" is asymmetrical, and its roof is formed of a sloping bed of impure limestone; but the majority, which form recesses along the major joint-planes, are beautifully regular. The lime-bearing water-films have formed the exquisite canopies and half-domes that shelter many of these alcoves; and to a similar origin must be ascribed the intricately moulded cornices, often many chains in length, that edge the more resistant rock-layers, which in turn generally support a luxuriant growth of fern and shrub.

Caves formed by sea-action are not so numerous. The cross-shaped cave called by the Maoris Te Ana-o-Matuku has been gnawed by the waves from massive breccia-conglomerate. It occurs a few chains south of the Fox River, and its floor lies about 15 ft. above the sea-level. As Haast* states, it "runs from north to south, is seventy-five paces long, ten paces broad, and 30 ft. high; from the middle another smaller branch runs towards the west, which is thirty-five paces long, and the entrance of which is washed by the sea." Other small caves are found at Cave and Razorback points. A notable blowhole occurs at the former headland, and another on Seal Island. The narrow chasm that forms one side of the ridge of Razorback Point was probably formed by the collapse of a sea-cave of considerable size.

* Haast, J. von: "Report of a Topographical and Geological Exploration of the Western Districts of the Nelson Province, New Zealand," 1861, p. 110.

CORRELATION OF THE WAVE-FORMED TERRACES OF THE SEA-FRONT WITH THE RIVER-FORMED TERRACES OF THE INLAND DEPRESSIONS.

The earth's crust is never at rest; elevation and stillstand are purely relative terms. The former implies a period during which the deformation of the crust, producing elevation of the land, proceeds more rapidly than the destroying agents can reduce it; the latter, on the other hand, implies a period during which marine erosion and subaerial denudation more than keep pace with deformation. In the Reefton Subdivision there are two lowland areas—the Grey-Inangahua and the Paparoa piedmont depressions—the floors of which are of weak strata, from which streams quickly carve a mature topography and develop extensive terraces. These weak strata are protected from marine erosion by belts of resistant rocks, through which the drainage-channels have cut their way. Thus no physiographical records of elevation, even if of great magnitude, can exist in the lowland areas unless the subsequent period of quiescence was of sufficient duration to permit of the larger streams cutting down their beds in the hard rock of their lower gorges. During such a lengthy period of rest the waves would cut a distinct rock terrace even in a hard rock, and during such a period marine and subaerial denudation would tend to remove the evidences of former pauses; yet, unless the later stillstands were of great duration, it would be unlikely that all traces of preceding ones would be removed. It has been stated above that the sea-front shows strand-lines at various heights above the present sea-level, and that marked sets of terraces occur in the Grey-Inangahua valley, and in the depression between the Paparoa Range and the Brighton plateau. It is not contended that each terrace is the dissected remnant of an ancient flood-plain. Most of them, in fact, are of merely local development, marking probably the down-stream migration of the meander-swings. Each terrace-set, however, is believed to represent part of the valley-floor lowlands of a particular erosion period, and an attempt will be made to correlate the various strand-lines with the series of terraces developed in the weak rocks of the inland depressions.

Rejuvenation Effects connected with the Present Standstill.

The last movement of the land, an elevation of about 10 ft., took place within very recent times. Thus the Omonehu, a small creek draining directly to the sea, has entrenched its old valley-floor only a few chains from the beach, while the Fox at low water flows over a rocky bar near its mouth. On the other hand, the Porarari, Punakaiki, and Ten-mile, streams similar in size, show only shingle-banks at low tide, the rock bars that probably exist being covered. Doubtless this recent elevation is the cause of all the streams being tidal for such short distances from their mouths: distances, in the case of the coastal streams, of a few chains only; in the case of the Grey, a mile and a quarter; and of the Buller, about three miles.

It is doubtful if the effects of so inconsiderable an elevation (*i.e.*, 10 ft.) could be recognized in the inland depressions, even if sufficient time had elapsed to permit the streams cutting back to them, and therefore for present purposes the existing and the 10 ft. strand-lines are considered together.

The period of rest that was responsible for the formation of the 10 ft. strand-line succeeded an uplift following on the standstill that is represented by the strand-line of the 80 ft. contour. It was of sufficient duration to allow the major streams to rejuvenate their lower courses for many miles. Thus in the coastal region the Fox, which may be taken as typical of all the cañon-forming streams, shows throughout its gorge scarcely a trace of any flood-plain older than its present one. Beyond the limestone gorge the mountain-torrents that unite to form the river flow over wide shingle-beds, and have removed all save meagre remnants of an extensive terrace-set standing from 20 ft. to 40 ft. above the present water-level, a fact indicating that the present stream-grade is greater than that existing at the close of what may for convenience be termed the 80 ft. standstill. Nearer the mountains the streams have cut for themselves narrow channels in the underlying Miocene strata, which in the case of Fox and Henniker creeks are wide enough to contain insignificant flood-plains, a feature entirely absent from the ditch through which Dilemma Creek hurries on its course.

The retrogression of the sea, from the 80 ft. to the 10 ft. strand-line, is marked along the Buller valley by the entrenchment of the river below an older valley-floor. This is well seen at Rocklands Flat, notably along the north bank of the river, and again from Inangahua Junction as far as the great bend in the Buller below Lyell Township. It is especially marked in the upper portion of the Lyell Gorge, above and below the junction of the Maruia, where the main road between Nelson and the West Coast runs on a rock-cut terrace beside a channel of which the steep granite banks have been swept clear of vegetation by the scour of innumerable floods. The entrenching due to this elevation extends up the Inangahua valley as far as Landing Creek, but beyond this the river-bed merges into a flood-plain formed during the standstill of the 80 ft. strand-line. All the creeks draining to the Buller and the entrenched portion of the Inangahua have cut down their lower courses for distances varying with their volumes, the nature of the underlying rock, and the time during which they have been engaged on the task.

In the Grey River system the elevation here considered has hardly yet made its effects manifest on the streams of the subdivision, although the rejuvenation due to this period may be plainly discerned at the Arnold junction and again in the lower course of the Blackball.

Rejuvenation Effects connected with the Standstill at the 80 ft. Strand-line.

The next well-marked strand-line developed above that at 80 ft. contours the shore-front at from 180 ft. to 250 ft. above sea-level. The elevation that brought the 200 ft. erosion period to a close initiated a rejuvenation of the streams, the effects of which may be readily traced in localities situated many miles from the sea. Along the coastal streams the terraces already mentioned as occurring above the gorge of the Fox belong to this period. Various terraces, in general apparently inextensive, were formed at this time above the gorge of the Porarari; but here—and this is a condition obtaining throughout the coastal region—the dense nature of the bush and the narrowness of the flood-plains makes the detection and reading of such minor surface lineaments a difficult and uncertain matter, except in the immediate vicinity of the travelling-ways—that is, along the creek-beds and tracks.

In the Buller River the dissected valley lowlands at Rocklands Flat and in the neighbourhood of Inangahua Junction belong to this period, as do the present flood-plains of the Inangahua and its tributaries from Landing Creek upwards, in so far as these traverse the Inangahua depression. As soon as the streams encounter the resistant rocks bordering the lowlands they become gorgy, and it has been found impossible to distinguish from one another the effects of the various waves of rejuvenation.

In the Grey basin the whole of the modern flood-plains within the lowlands belong to this period of rejuvenation, and, on the whole, the phenomena exhibited closely simulate those existing in the Buller valley. The principal difference lies in the fact that the present flood-plains are more sharply distinct from the valley lowlands of the 200 ft. period in the Grey than in the Inangahua system. This feature is but a function of the maturer stage of development reached by the Grey and Mawheraiti.

It is upon the flood-plains and low terraces of the erosion period here considered that the railway and arterial roads of the subdivision are placed, and the heights of the railway-stations may be used to show the grade of the main waterways at the close of this pause in the uplift of the land. A comparison of the amounts of cutting and embankment required respectively in the Grey and Inangahua valleys in connection with the construction-work of the railway brings out forcibly the effect a slight difference in the degree of maturity of a river-valley may have upon human affairs.

REJUVENATION EFFECTS CONNECTED WITH THE STANDSTILL AT THE 200 FT. STRAND-LINE.

The pause in elevation at the 200 ft. contour is represented in the coastal region not only by a very prominent strand-line, approximately at that height above sea-level, but also by terraces in the depression along the western foot of the Paparoa Range. In the case of the Fox the difficulties of observation and the limited time at the writer's disposal have militated against adequate description. An admirable example, however, of valley lowlands due to this period exists in the gravel-strewn depression between the middle courses of Porarari River and Bullock Creek. The inland track makes use of this natural feature, and rises from the stream-level of the Porarari at the Cave Creek junction (40 ft. above sea-level) to a terrace-set from 100 ft. to 150 ft. above sea-level, probably formed by the Porarari during the 80 ft. erosion period. Another series of terraces, however, has to be surmounted before reaching Bullock Creek, and these attain a height above the sea of from 320 ft. to 360 ft. Both terrace-sets are traversed by the deep narrow ditch in which Cave Creek flows, and the higher is more or less dissected by several small streams that have cut through the gravels into the underlying claystone. It is suggested that the latter series was formed during the 200 ft. period by Bullock Creek, which then flowed in a normal manner to join the Porarari, and that its present underground course is of a later date.

Along the valley of the Buller River proper, in contradistinction to the valleys of its tributaries, the only terraces which may be referred to the 200 ft. erosion period are those occurring in the vicinity of Rocklands Flat. At its eastern end, where the river sets hard against the left bank, a cliff of soft calcareous mudstone 120 ft. high forms the base of a tableland 200 ft. above the water-level. This is quite inextensive, and forms only part of the gathering-ground of the stream that gushes from a hole in the cliff just above the road. The northern portion of Rocklands Flat is formed by a fairly wide terrace-set now in part drained by the Orikaka. The ox-bow lake lying on it, however, indicates a meander curve of a radius too great to have belonged to any river other than the Buller. All trace of any other valley lowlands formed during the period now considered seems to have been removed by the river during its subsequent downcutting. In the Inangahua valley, however, massive blocks of terrace-sets, rising to a height appropriate to this period, exist between the branch streams from Inangahua Junction to Reefton.

In the Grey basin terraces belonging to this series have an even more extensive development, and form the most prominent physiographical feature of the low country. Large areas of their surface are swampy and destitute of forest growth, while much of what remains is covered by stunted scrub. The early settlers termed these high-level terraces "plains," as much on account of their open swampy character as on account of their flatness. Thus along the western side of the Grey valley the moor stretching from the head of the Mawheraiti to the Whitefoord is known as the Maimai Plain, that along Burton Creek as McHardy's Plain, and that north of the Otututu as Mirfin's Plain. The swampy terrace land drained by the Craigieburn is known as the Craigieburn Pakihi, while that forming a small area between Caledonia and

[*Photo by W. Sherlock.*

PLATE IV.—VIEW OF REEFTON LOOKING DOWN THE INANGAHUA VALLEY, SHOWING TERRACES 200 FT. AND 600 FT. ABOVE THE STREAM-LEVEL, AND ON THE RIGHT THE GRADATION OF THE HIGHER TERRACE INTO THE REEFTON HILLS.

Face p. 48.]

Baxter creeks does not appear to have received a name. On the other side of the valley the Ikamatua Plain lies between the Mawheraiti and the Big Grey, while south of the latter river is Mackley's Plain. The terraces at the back of Raupo are known as the Ohinetakitaki Plain, and this merges southwards into the Ahaura Plains, which stretch for several miles along the banks of the river to which they owe their name. It should be noted that similar open spaces are to be found on the Inangahua valley on terraces of this period. These are most extensive between the Waitahu River and Boatman Creek, and, in conjunction with the unforested areas belonging to the present valley lowlands just north of the former stream, constituted the Oweka Plains of Brunner and Haast. This name is, however, also applied to the lowland country, treeless in patches, lying between the Inangahua River and the Brunner Range.

Rejuvenation Effects connected with the Standstill at the 500 ft. Strand-line.

Along the shore-front marine beach-gravels occur, as already described, at many places at heights varying from 400 ft. to 600 ft. above the present sea-level. These mark a stillstand, or rather a period of relatively unimportant earth-movements, and have a much greater development to the northward in the Charleston-Addison district, where sea-built terraces some miles in width stretch along the mountain-base southward from the Buller. An arm of this area extends into the basin of the Fox, where the writer is informed blacksand-leads exist at a height of about 600 ft. above sea-level. The old marine beaches that once formed wide-spreading flats in this locality have been covered to a great extent by stream-gravels from the mountains, and afterwards the whole has been sculptured by subaerial denudation during the succeeding erosion periods. The result is an assemblage of hillocks, of which only the equality of height suggests their derivation from continuous lowlands. Similar remarks apply to the high-level stream-gravels which occur at many points on the ridges within the piedmont depression. From the land-forms alone, without the evidence furnished by the nature of the deposits, it would be difficult to maintain that streams ever flowed in mature graded valleys at such a height in this locality.

Along the Buller River system, and especially in the Inangahua valley, great terraces exist between the tributaries fully 500 ft. above the present main drainage-channels. Such terraces occur against the hills and mountains bounding the depression, and form a terrace-set sharply distinguishable from the series next below it. Their distribution has already been sufficiently indicated.

In the Grey basin terraces referred to this period are represented by the tableland lying between the Snowy River and the Blackwater. The wide terrace between the former stream and Mossy Creek, though of slightly lower elevation, must probably also be considered here. The well-sculptured hills that south of the Big Grey rise above the so-called plains of that region have been carved from ancient valley lowlands of a similar height. In the valley of the Mawheraiti, and along the western side of the Mawheranui, stream erosion during the 200 ft. period has removed all but the merest remnants of this, the oldest terrace series of which the form may still be traced.

The senile topography of the high-level portions of the Reefton and Orikaka hills is undoubtedly the result of long-continued denudation during this period. The gentle manner in which the hills rise from old terrace-surfaces in the catenary curves of mature adjustment strikingly attest this, and prove its long continuance.

Conclusion.

The writer, as soon as he had conceived the possibility of correlating the strand-lines of the coast with the terrace-sets of the Grey-Inangahua depression, commenced the systematic observation of terrace-heights during field-work, in order to give a quantitative as well as a qualitative value to the phenomena attending the development of the different interrupted erosion cycles. It was soon found, however, that such work to be adequately performed would consume more time than was available. Nevertheless the data collected, while not sufficient for an authoritative discussion of all the conclusions, yet enable several general inferences to be drawn and some puzzling physiographical features to be explained.

The Buller is very much larger than the Grey, and has a much greater corrosive power. Conclusive proof of this is provided by the fact that since the last material elevation of the land rejuvenation has progressed in the Buller to the Four-river Plain, over fifty miles from the sea, while the corresponding distance in the Grey River is barely eighteen miles. This great disparity exists in spite of the fact that the down-cutting of the Buller has been effected along a course through twenty-two miles of hard rock and twenty-one miles of moderately resistant strata, while the figures for the Grey are five and four miles respectively, the balance of cutting in each case being through loose gravel. In considering the work of the Buller, the fact that this river, unlike the Grey, has nowhere within its lower valley had an opportunity of aggrading on the grand scale makes strict comparison of the streams impossible, but analogies may fairly be drawn between the Inangahua and the Mawheraiti, in so far as their lower valleys are concerned. The Inangahua is decidedly the larger stream, and has in the present erosion period already entrenched its bed for six miles from the junction with the Buller, whereas the rejuvenation rapids of the main Grey are still five miles from the Mawheraiti junction. It cannot be doubted but that the Inangahua enjoyed a similar advantage in the preceding rejuvenation periods, and it is natural to expect the valley lowlands due to each period to have reached a more mature stage than the corresponding features in the Mawheraiti. The reverse, however, is the case. The reason is not far to seek; it lies in the fact that moderately resistant rocks are much closer beneath the gravels in the Inangahua than in the Mawheraiti valley. This is very patent below the Landing Creek junction, to which point the rejuvenating influence of the last uplift has made itself felt. Above this, however, the conditions are strictly comparable with those existing along the Mawheraiti. As each tributary of the former river is traced from the parent stream the underlying beds are found to protrude long before the edges of the depression are reached. Indeed, the swing of the main river also exposes these beds at a few points. In the Mawheraiti, on the other hand, consolidated strata outcrop in the branch streams only as they approach the hills. The observations pertinent to these statements are tabulated below :—

Cross-section of trough at—	Width between Outcrops. Chains.	Elevation of Main Drainage-channel. Ft.
Larry Creek junction	110	440
Giles Creek junction	180	460
One mile above Waitahu junction	220	550
Maimai junction (Grey River)	340	540
Burton Creek junction	400	430
One mile below Little Grey junction	450	260

The writer considers that the facts are most satisfactorily explained by postulating the existence of a great valley belonging to a river that flowed southward along the great depression over the sites of the present Inangahua and Mawheraiti. This valley was filled by gravels prior to any of the erosion periods hitherto mentioned, and is now in process of re-excavation. The drainage of the northern portion of this valley, however, must have been diverted through the Buller Gorge prior to any of the erosion periods described above.

[*Photo by W. Sherlock.*

[*Photo by J. Ring.*

PLATE V.

FIG. 1.—VIEW OF JUNCTION OF THE BIG GREY AND MAWHERAITI RIVERS, SHOWING TERRACES AND THE EVEN SKY-LINE OF THE PAPAROA RANGE.

FIG. 2.—JUNCTION OF THE BULLER AND INANGAHUA RIVERS, WITH BOUNDARY PEAK IN THE DISTANCE AND PART OF THE ORIKAKA HILLS ON THE LEFT.

Face p. 50.]

The entrenchment of the streams beneath the base-levelled surface of the Reefton and Orikaka uplands has already been commented upon. No attempt, however, has been made to trace within them the effects of the various erosion periods; indeed, from the time the rejuvenating influence of the uplift terminating the 500 ft. period reached the hard rock of the upper valley of a stream, the energies of that stream have probably been absorbed in the downcutting of its valley. Only in the case of the Inangahua and Waitahu have terraces of more than the most limited extent been formed, and these have been doubtfully ascribed by the writer to the 200 ft. erosion period. The distance each stream has proceeded with its work of gorge-cutting is a function of its volume, the time of erosion, and the nature of the underlying rock. Some have destroyed all trace of their ancient valleys, but many, as has already been stated, still have mature headwater valleys in the uplands beyond their youthful gorges. To the first class belong all the streams of the coastal region with the exception of the Waitakere, which still preserves at its very source a short section of the ancient glaciated trough wherein it takes its rise. In the Grey basin a comparison of the tributaries from the west as they successively leave the Paparoa Range is most instructive. These from the lower ends of their intermontane gorges traverse rocks of fairly uniform hardness, and the features of physiography may on this account be reduced to tabular form. From this table the Roaring Meg and the Pike streams have been omitted, the first on account of its abnormal history,* and the second because so much of its course is in rock differing in resisting-power from that through which the other streams have had to cut their gorges.

Name of Stream.	Distance of Lower End of Gorge from Stillwater, in Miles.	Length of Gorge, in Miles.	Length of Old Valley above the Gorge, in Miles.	Area of Intermontane Basin, in Square Miles.	Height at which the Gorge reaches the Old Valley-floor, in Feet above Sea-level.
Blackball	6·50	3·00	2·50	8·70	1,000
Moonlight	13·00	3·00	2·50	12·50	1,010
Freeth	17·00	4·00	2·75	10·00	1,400
Mirfin	22·50	1·25	1·50	2·84	2,000
Otututu	23·00	2·50	10·00	45·20	920
Burton	24·00	1·00	1·25	2·20	2,420
Whitefoord ..	27·00	2·00	3·50	8·37	1,980
Maimai	29·50	1·50	3·00	5·75	2,050
Giles	32·50	0·75	2·50	3·85	2,060

ALTERATIONS IN DRAINAGE.

Perhaps the most obvious example of stream-piracy is that furnished by the portion of the Inangahua above Reefton. The section of the river between Reefton and Stevenson's Flat flows at first northward for several miles along the foot of the mountains before turning more to the westward and cutting through the Reefton hills. The tributaries in this portion of its course are, with one exception, small, and those from the right have this in common: that all have their upper valleys wide, shallow, and very much more mature than the narrow tempestuous gorges by which they link themselves to the Inangahua. This distinction applies to the Murray, Lankey, Scottie, Garvey, McConnochie creeks, and also to Tobin (or Rough) Creek, the large stream referred to above. The tributaries from the left valley-flank are streams analogous in size to those from the right, drain a similar set of uplands,

* See p. 53.

and have similar courses, except that in no case is the headwater more mature than any other portion of the valley. It is suggested that the present valley of the Inangahua is a comparatively modern feature, younger than the mature headwaters of the streams from the east. These branches formerly flowed westward or south-westward across the present site of the Inangahua, and joined the tributaries of the Mawheraiti that drain the uplands in this locality. It is for this reason that the small streams from the west have immature valleys to their very heads. There is one exception to this. Deep Creek in cutting back captured a creek that once drained to Carr Creek, and this stream still has its mature upper valley, and flows in a direction nearly at right angles to what would be the course of a normally developed tributary of Deep Creek. A prominent elbow of capture is to be noticed in connection with the same stream, and similar elbows occur in Rainy and Auld creeks, the former of which used to drain to Devil Creek, while the latter flowed along the mature valley that can be traced from the head of Portugee Creek to Reefton. The tributaries of the Mawheraiti from the uplands in this locality have several peculiarities. Their headwaters drain from saddles which are also reached by branches from the Inangahua, and there is no interlocking of opposing head-waters of streams from the Grey and Buller basins. A like condition prevails at the headwaters of Devil Creek, which are opposed by Union and Rainy creeks. The most prominent saddle is that between Deep Creek and a small branch of Carr Creek, but others occur at the heads of Slab Hut and Absolum creeks and the Big and Snowy rivers. It should be noted that above Deep Creek the streams to the Inangahua from the saddles are very small, suggesting that a decided interval of time elapsed after the capture of Tobin Creek before the intermontane stream at present forming the headwaters of the Inangahua was diverted from its course down Absolum Creek to the Grey. The saddles between the basins of the Snowy and the Alexander and the valley of the Inangahua are 2,350 ft. and 2,300 ft. above sea-level respectively, while the stream-level below is from 1,080 ft. to 1,160 ft. This indicates that the streams were beheaded not later than during the 500 ft. erosion period, and probably considerably earlier.

The valleys heading to the saddles above mentioned are much too large for the streams they now contain. This is peculiarly noticeable when branches leave the main valley. In the case of the Alexander the principal stream turns abruptly into the mountains, while Absolum Creek, a far smaller stream, continues the direction of the lower valley to the saddle. It flows beneath an older mature valley, in the gravels of which it is sufficiently entrenched to show occasional outcrops of the underlying rock. Snowy River splits into two nearly equal headwater branches, of which the one follows the general course of the stream in a wide valley showing no outcrops, while the other coming from the southward exposes a continuous section of granite in a valley still youthful. The Big River has its source in swampy country of senile relief that slopes gently upward toward the valley of the Inangahua. Low hills rise above this surface, and its abrupt eastern edge is gashed by small feeders of the Buller system. The features observed suggest that the Big River has lost little territory to the Inangahua, an hypothesis supported by the character of its valley as compared with that of the Snowy, a stream of equal size and flowing across the same rocks. The valley of the Big River is little better than a tortuous trench, the sides of which show constant slips, while that of the latter is much straighter, hundreds of feet deeper, and decidedly less youthful. It would seem that the Snowy before it was beheaded received the drainage of the mountain-flank between Tobin Creek and the upper Inangahua, and had succeeded in deepening its valley considerably in advance of the Big River before being deprived of this material assistance. Tobin

Creek flowed to the Grey probably by way of the Deep Creek saddle, which for this reason is about 300 ft. lower than that at the head of Slab Hut Creek, the lost head of this latter stream being probably Garvey Creek. Lankey Creek similarly once joined Oriental Creek, the gravelled flats on which Cornishtown is built being a remnant of its wide mature valley-floor. Devil Creek at this time emptied into the Mawheraiti near Tawhai. Murray Creek, with some assistance from Auld Creek, is responsible for the high-level gravels at the head of Liverpool Dave Creek, but that it followed the course of that stream is doubtful.

Besides capturing streams draining to the Grey from Victoria Range to its own channel, the Inangahua has also annexed from the Mawheraiti at least one considerable stream from the Paparoas. Giles Creek has a very prominent elbow of capture at the base of the mountains, and the depression followed by the first-made pack-track from the Mawheraiti to the Inangahua is the old dissected high-level valley of this stream.

The piedmont depression lying to the west of the Paparoa Range has seen as many, perhaps more, changes in drainage than even the disputed territory lying near the watershed of the Inangahua and Mawheraiti. The data available, however, are too scanty for an adequate discussion of this problem, and the views here expressed must be considered tentative only. The distribution of the beach-gravels containing blacksand makes it certain that during the 500 ft. erosion period a shallow arm of the sea penetrated from the north, between the mountains and the limestone hills of the coast, as far south as the basin of the Fox. It is probable that during at least part of the 200 ft. period the streams drained northward into an ancient river-system now represented by the Waitakere and Four-mile streams. The cañon of the Fox through the coastal plateau follows a structural hollow; and it seems likely that the position of this feature was determined by fissures or incipient fissures along the trough offering a readier access to the sea than that afforded by the Waitakere or Four-mile streams, which had to deepen their lower courses through gneissic granite.

The drainage history of the southern portion of the piedmont depression presents a much more difficult problem. It is separated from the northern section by a rather narrow ridge-like plateau edged with vertical cliffs, the surface of which is mature-looking, and in places at least is veneered with ancient gravels. Whether these were deposited during the 500 ft. erosion period or at an earlier time is not known, nor can the direction of flow of the old streams be certainly determined. The gravels themselves consist chiefly of greywacke and argillite; and since in this region the only large area of such rocks lies to the southward, it is suggested that the sea-inlet above referred to occupied a depression which extended southward as a river-valley that included the headwaters of the present Porarari and Punakaiki.

A very obvious instance of domestic piracy is furnished by the upper Roaring Meg which once joined the left-hand headwater branch of Blackball Creek, while the means by which the stream-diversion was effected may also be definitely stated. The upper valley of the Roaring Meg is well graded, and at its lower end, where the water-level is approximately 2,000 ft. above sea-level, contains a little lake—Lake Margaret—and a small swampy flat. On the other hand, so far as the Reefton Subdivision is concerned, the middle valley of this stream is rivalled in narrowness and difficulty only by the upper portion of Bullock Creek, a stream traversing a type of rock that tends to produce gorgy valleys. The saddle leading to the Blackball is barely 50 ft. above the stream; and so narrow is the ridge separating the watersheds that a tunnel about 100 ft. in length has been driven from a small tributary of the Blackball, and the Meg may be turned at will down this stream. The left branch of the Blackball is entrenched in a gravel-deposit and shows only occasional outcrops, while the rill which forms its actual source turns suddenly southward up the mountain-slope. The hypothesis that suits all the facts postulates that a great slip that filled the old valley, and caused the dammed-up Meg to take its present course, has come from the steep hillside to the southward. This accounts for the occurrence of the pond and swamp, features unique in the subdivision for such a portion of an intermontane valley. It is possible that the present course of the Meg is a reversion to its original valley, the Blackball having extended its territory by cutting back along the fault-zone from which the loose rock of the slip originated. It is difficult to account otherwise for the existence of a valley-head in a mountain region separated from a stream of the size of the Meg by a saddle of less height than that now existing at the head of the Blackball.

One other case of drainage-diversion deserves mention. Lake Rahui, a half-filled-in ox-bow lake formed by the Buller during the 200 ft. erosion period, formerly drained down Muddy Creek. The Wellington Sluicing Company formed a race to tap it, and constructed a dam to raise the surface of the water. The lake then brimmed over, and now discharges into the small tributary of the Orikaka joining that river a few chains above its junction with the Buller.

CHAPTER IV.

FAULTING, LODE-COURSES, AND STRUCTURE.

INTRODUCTION.

In the chapter on physiography prominence was given to the surface forms which are believed to be controlled by underground structures. The observer cannot but be struck by the abruptness with which the mountains rise from the lowlands, and the simplicity of their base-lines. Again, the great longitudinal depressions that traverse the mountain regions are remarkable features. The first outcrop encountered in the intermontane valley of the Otututu consists of soft pug, well banded and containing angular fragments of granite. This rock (using the term in its geological sense) has a meridional strike with a vertical dip, and continues for several chains; it is, in fact, comminuted granite filling a great fracture. As the geologist extends his observations more widely over the district it becomes increasingly manifest that great fracture-zones have a most profound influence on the physiography of the subdivision.

McKay was the first to point out the great part that faulting, as opposed to folding, had played in the Tertiary history of New Zealand. His paper of 1890* described many of the major faults of New Zealand. Although, from lack of the necessary data, some of the correlations he made between widely separated fracture-zones are known to be mistaken, yet his labours in this field have laid the foundation on which all further work must rest. Morgan in the North Westland Division, Webb and Morgan in the Westport Division, and the present writer in West Nelson as a whole, have traced the course of the major faults of the district in greater detail than could be attempted by McKay.

The criteria for the detection of faults are geological and physiographical. Until recent years the physiographical evidences of faulting were looked upon with strong disfavour by some geologists, but so many proofs of their value have been obtained that it is now generally recognized that even without geological data they may furnish conclusive proof concerning the existence and course of faults. In the Reefton Subdivision, however, it is almost always possible, as examination is more widely extended, to find positive evidence of faulting somewhere along the course of a great fracture, and the physiographic features are then of the utmost value in determining the strike of the fracture.

AGE AND NATURE OF THE FAULTS.

The geology of the Reefton Subdivision will be described in the next chapter, and it will suffice here to give a brief summary of its main features. Thick beds of Palæozoic greywacke and argillite, with which are associated, over a small area,

* McKay, A. : "On the Geology of Marlborough and South-east Nelson." Rep. G.S., No. 21, 1892, pp. 1–22.

quartzite, argillite, and limestone containing Devonian fossils, constitute the basement rocks of the subdivision. Vast masses of acidic igneous rocks were intruded into these strata, and long-continued subaerial denudation has brought about their exposure over great areas. Subsequent crustal stresses, perhaps due to the cooling of the magma, found relief in the formation of great fracture-zones, in the fissures of which auriferous quartz was deposited. The extensive mining operations of the district have disclosed the general trend of these ancient fault-systems. No deposits of Secondary age are known within the subdivision, and the beds overlying the greywacke and granites were laid down in the Eocene. They consist of breccias, conglomerates, grits, and sandstones, which in this district have no great areal extension. Of much greater importance is a thick series of rocks that, in upward sequence, displays conglomerates, grits, sandstones, mudstones with their gradations, and then again claystones, sandstones, and in some parts conglomerates. These beds are believed to range from Miocene into the Pliocene. Gravels—marine, fluviatile, and morainic—overlie with great unconformity, and complete the geological record.

It is not proposed in this chapter to discuss at length the evidence on which the statements of the age of the fault-systems are based; for this the reader is referred to later pages. The earlier faults are, of course, not nearly so well known as the later ones, since Tertiary and later deposits must conceal them to a great extent. In regard to the dislocations affecting the Tertiary strata, from direct evidence it is known only that post-Pliocene movements have taken place. Other lines of reasoning, however, lead to the conclusion that at least four periods of faulting occurred during Tertiary times. These periods were, approximately, just prior to the Eocene deposition, just prior to the Miocene, between Miocene and Pliocene, and again after the Pliocene. Later movements of the land, although of considerable magnitude, as indicated by the physiography, do not seem to have been attended with faulting on the West Coast.

The faults present the usual characteristics. The movement, even along the same dislocation, may be concentrated in a single fracture with walls close together or perhaps several chains apart, the intervening space being filled with comminuted rock containing numerous angular fragments from the walls. These fragments may increase until the gouge is quite secondary, when a fault-breccia results. Sometimes the fragments are rounded, and these may be sufficiently numerous to simulate a conglomerate. Again, the fault may be a shear-zone with numerous subparallel and closely spaced polished surfaces, with the intervening rock rendered schistose and always more or less deformed. Again, the rock-sheets may increase in size and be but little distorted. When such occurrences merge into single-fracture dislocations the total downward movement of the depressed block is not sensibly different, the minor breaks being complementary. One type of fault constantly recurs—narrow trough faults—in which the rock between the main-fault walls belongs to a higher horizon than the walls themselves. When the Tertiary beds which overlie the Palæozoic sediments and granites are involved the detection of this type of fault is very easy.

The main fracture-planes nowhere appear to deviate far from the vertical, and, although no definite proof can be adduced for the statement, the writer believes the fault-movements to have been essentially normal. There are numerous well-marked examples of faults with varying throw, while the occurrence of hinge faults is also suspected. These types will be pointed out as each fault is described.

PRE-TERTIARY FAULT-ZONES.

Introduction.

The pre-Tertiary faults are recognizable with certainty only when the fissures have been filled with igneous rock, cemented by quartz veins, or have the fissure-walls impregnated with mineral. The dykes seem to have penetrated the fractures as tongues, and not as continuous sheets, and on this account they have not proved so valuable as sources of evidence as the deposits and impregnations of mineralizing solutions. That the earth-movements which produced these faults were spread over long periods of time is certain, and it is probable that at least two separate and distinct intervals of quiescence occurred during their formation. The crustal stresses of the different periods were relieved, however, by movements of a similar nature and along the established zones of dislocation. Diabase dykes are considered to mark the fractures by which relief was given at the time of the intrusion of the igneous magma. After these had consolidated a further movement extended the fractures, crushing some of the dykes and also bringing other fissures into existence. Along these auriferous quartz was deposited, the nature of which proves, for the period of their formation, a state of inequilibrium and frequent small movements between the fissure-walls.

Reefton Fault-zones.

The best-known pre-Tertiary fault-zones of the subdivision are those that contain the auriferous lodes of Reefton, and which stretch from north of Landing Creek to the Snowy River, a distance of nearly twenty-five miles. They consist of two parallel and partly overlapping zones or runs* of intensely faulted rock, containing many diabase dykes and innumerable quartz lodes. The eastern subzone stretches from Landing Creek to the upper valley of Snowy River, a distance of about twenty miles, the strike of the whole being about N. 13° E. Its outermost fractures on the west are probably small, and are very imperfectly known, but the width of the belt is at least from 80 chains to 100 chains. The dip of the majority of the individual fault-planes is to the westward; and the writer suggests that originally all were in this direction, and that powerful Tertiary fault-movements are responsible for the eastward dips of the lodes in the Boatman and Big River districts. The strikes of the individual planes do not conform with the general strike of the zone. Thus from Landing Creek to Raglan Creek the planes strike nearly N. 10° W.; from Boatman Creek to Murray Creek, N. 5°–25° E.; from Murray Creek to Slab Hut Creek, N. 8° W.; and from Slab Hut Creek to Snowy River, N. 18°–45° W. This arrangement closely corresponds with the fractures produced in a homogeneous solid by a torsional stress.† In nature such a series of fractures results when a stress crosses obliquely the folds, fractures, or incipient fractures produced by a former stress.

To return to the main theme: The western zone stretches from Devil Creek to south of Snowy River, a distance of twelve miles. It lies parallel to and overlaps for nearly nine miles the eastern zone, from which it is separated by a belt of hard greywacke about two miles wide, containing few fracture-planes. The dip of the fault-planes is to the westward, and their strike east of north to an extent varying between 24° and 30°. It must be noted that, as in the eastern fault-zone, though to a somewhat less extent, the strike of the individual planes varies decidedly from that of the zone in general.

Another important pre-Tertiary fault-zone is that on which occur the quartz lodes of Kirwan's Hill, McConnochie Creek, and the Alexander River. The mineralized granite outcropping in a small branch of Tobin Creek must also be here included. There are indications of its extension northward into the north branch of Larry Creek, and the zone has thus been traced a distance of about twenty miles. Its

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* For definition of "run" see p. 115.

† See A. Daubrée: Études Synthetiques de Géologie Expérimentale," Paris, 1879; quoted in Émile Haug's "Traité de Géologie," vol. i, 1907, p. 226, &c. See also E. Suess: "Das Antlitz der Erde," English translation, vol. i, 1904, p. 122.

strike as a whole is about N. 11° E., while most of the lodes of Kirwan's Hill strike about N. 22° E. The block of country separating this zone from the Reefton fault-zone has an average width of about four miles, and consists in the north and south chiefly of granite, while in the central portion it is largely of Palæozoic sediments intruded by the granite that outcrops over a small area in the valley of the Waitahu, about a mile below the forks of that river.

Paparoa Fault-zones.

The most southerly portion of the Paparoa Range within the subdivision was in pre-Tertiary times affected by powerful stresses, and the fractures produced thereby now contain dykes of basic rock or quartz veins. Of these, the latter are reported to be well exposed on the alpine meadow-lands near the sources of the Ten-mile, Blackball, and Moonlight creeks. The writer visited these inhospitable regions in May of 1913, at a time when a heavy fall of snow entirely hid all outcrops, and unfortunately no later opportunity presented itself for further examining the locality.

McKay says, " There are six or seven distinct lines of quartz reefs with accompanying leaders or veins. All of them have an east-and-west direction, and as a rule dip to the north."* The writer's observations in the lower-lying country confirm this statement, provided that " east and west " be considered to be magnetic east and west.

The most northerly mineralized zone, according to McKay, crosses the range into the north headwater branch of Moonlight Creek, where an auriferous lode striking about 110° has been discovered. Other large lodes with similar orientation exist in the spur to the southward. A small diabase dyke with a strike of 103° outcrops near the Moonlight forks, and the large dyke observed in the valley of Canoe Creek, six miles from its mouth, probably also belongs to this belt. The run has a width of about half a mile, and a length between the limits here described of about five miles. McKay's next " line,"† outcropping between the heads of Canoe and Moonlight creeks, the present writer is inclined to group with that immediately to the southward. Quartz lodes belonging to these " lines " traverse the ridge between the Roaring Meg and the Moonlight, and again appear on the ridge on which is situated Trigonometrical Station P and in the headwaters of McCarthy Creek, the length of the whole series being about seven miles. It is probable that Fagin Creek and the head of the Roaring Meg are fault-line valleys excavated along a powerful dislocation. This supposition is supported by the distribution of the granite and sedimentary rocks in the Fagin Creek valley at the western extremity of the line, and by the loose diabase and the many quartz lodes occurring near and north of the saddle between the Roaring Meg and Blackball streams. The writer, however, has had no opportunity of examining Mount Ryall, where evidences of fracturing should also occur. The next " line " follows the north-east side of the right headwater branch of Blackball Creek. According to McKay, quartz veins belonging to this series do not outcrop along the Ten-mile Stream, but towards the Upper Blackball Township lodes up to 40 ft. in thickness may be traced for a distance of from one and three-quarters to two miles. To this lode-series may be referred the large quartz lode outcropping in the savage gorge of the Roaring Meg, an occurrence making it traceable for about six miles. The Minerva lode, outcropping in the Blackball Creek just within the subdivision, belongs to another series of lodes, which has representatives towards the east in the quartz veins near the lower end of the gorge of the Roaring Meg and in German Gully. To its western extension may be referred the veins near the head of Smoke-Ho and Otto creeks.

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* McKay, A. : " Geology of the South-west Part of Nelson and the Northern Part of the Westland District." C.–13, 1895, p. 27.

† For definition see p. 115

The length of this series is thus five miles, and the width rather more than half a mile. The lodes of Langdon Creek, six miles south of the southern boundary of the subdivision, have an orientation similar to that of the various lode-series above described, and probably are structurally connected with them.

Besides the above-mentioned belts of dislocation, all of which have a strike a little south of east, another system of fractures exist striking a little west of north. The first, which may be termed the Garden Gully lode-series, shows numerous quartz-filled fissures in Garden Gully and McCarthy Creek. It is continued northward by the quartz veins outcropping above the township of Moonlight. The next series of lodes lies 100 chains to the westward and somewhat to the northward, and may be termed the Upper Moonlight series, from the fact that it crosses the three streams that unite to form Moonlight Creek. Veins that probably belong to it are reported to outcrop on the steep spur lying to the west of the head of the Punakaiki River, and doubtless these have furnished the shoad quartz so abundant in the upper valley of that stream. Although the series strikes west of north, most of the lodes belonging to it have courses a little to the east of north—that is, at right angles to the direction of the other group of lode-series, one of which has already been described as appearing in this locality. Another series—probably belonging to the second system, but one of which, as the writer has already explained, he has no personal knowledge—is that to which belong the auriferous lodes in the Taffy and Crœsus claims. In the Crœsus the strike of the lode is nearly due north, and the dip is eastward at about 35°. In the Taffy the leader-zone strikes west of north, and has a steep dip to the north-east.

TERTIARY FAULTS.

The Tertiary and post-Tertiary faults include also those that were formed just prior to the deposition of the lowest Tertiary strata. Although the rocks of the subdivision have been affected by at least four periods of crustal stress during the Tertiary, it is rarely possible to prove any fracture older than the latest period of movement. It is probable that all the deformations were of a like nature, and that once the zones of fracture were established the subsequent stresses would tend to find relief along the old ruptures. In the neighbourhood of Reefton it can be demonstrated that many Tertiary faults follow pre-Tertiary fractures, and there is a strong probability of a like origin for many dislocations in other parts of the subdivision.

The principal ruptures active during Tertiary times are those separating areas of different elevation. Thus the Paparoa Range is bounded both on the east and the west by great fractures, or rather series of fractures, arranged essentially in step-fashion, and a similar structure prevails along the western edge of the Brunner-Victoria Range. A more complex structure is exhibited at decided bends in the mountain base-line, where the change in direction is effected either by definite diagonal faults or by the ramification of fractures that in other portions of their course are relatively simple. The hill groups described in a preceding chapter are also separated from the mountains and lowlands by faults. This is demonstrably the case in many localities, and is probable in many others.

The general course of the Lower Buller fault, which limits the Paparoa Range on the west, was indicated by McKay* in 1890. Webb† in 1910 described a portion of it as the Kongahu fault, and Morgan and Bartrum‡ have mapped it for nearly fifty miles. It enters the Reefton Subdivision apparently as a simple fracture, but soon other parallel breaks appear, and it becomes difficult to distinguish along which the greatest

* Rep. of Geol. Explor. 1890–91, No. 21, 1892, p. 22. † N.Z. G.S. Bull. No. 11, 1910, p. 11.
‡ N.Z. G.S. Bull. No 17, 1915, p. 62.

movement has taken place. If it be assumed, however, that the main break limits the Tertiary strata on the east, the Lower Buller fault runs into the sea near Maukurunui Bluff.

The faulting mentioned by Morgan* as occurring in the Seven-mile, Spring, and Tararu creeks is continued northward along the upper valley of the Ten-mile. To this fault must be attributed the broken country of the Taffy Claim, and in the head of the Punakaiki, as well as the great precipice facing the upper valley of that stream. This line of faulting was also traced in the Porarari and Bullock Creek, but the traverses of the heads of the Fox River were not pushed far enough to intersect it. The fault-zone, moreover, appeared to be dying out northward.

Another fault-zone of which the displacement certainly diminishes northward is the Roa fault. According to Morgan† this fault at Smoke-Ho Creek, on the boundary of the Reefton Subdivision, has an easterly downthrow of over 3,000 ft. This rapidly decreases, and apparently gives place to a westerly downthrow between Mount Hawera and The White Knight, a hinge fault being thus formed. The line continued northward traverses some of the wildest country in the Paparoas, in which proofs of faulting are obscured by vast talus-deposits; nevertheless, fault-indications were noted near the head of the Waitakere, and the line may be continued into the valley of the Ohikanui, which is probably a fault-line valley.

Morgan† describes a fault that distorts strata at Blackball and Healy Gully. In the lower valley of the Moonlight this fault has an easterly downthrow of at least 2,000 ft. Farther north the displacement is distributed among several fractures, which diverge and ultimately become as important as the original fault, across which the Big or Freeth River has cut its way, while the Otututu has probably carved its upper valley along it. The fault which follows the upper valley of the Te Wharau, if not the same fracture, is certainly on the same zone, which again appears in the valley of the Blackwater (tributary of the Buller).

A branch fault that originates from the last-mentioned fracture may be traced in the branches of the Freeth River, and again in the Mirfin, Rough-and-Tumble, and Whitefoord streams. Farther north no positive evidence of its presence was observed, but the low saddles near the heads of the Whitefoord, Maimai, and Giles creeks, the depression west of Mount Steele, and the vast quantities of slickensided débris discharged into the gorge of the Te Wharau by a small branch, are highly suggestive of its continued existence.

Another fault of great importance also has its southern end in the basin of the Freeth River. This, which may be termed the Paparoa fault, acts as a peripheral fault along the eastern base of that range for many miles. North of the Maimai Stream it loses its simple character and is represented by at least two important fractures, which enclose a block of tilted country half a mile in width. Farther north other breaks with a more easterly trend appear, while the western faults seem to die out, the net result being a change in direction of the main dislocation. This great fault-zone is lost, however, beneath the gravels of the lower Inangahua, but it is probable that several faults at the head of Welshman Creek and on the lower valley of Pensini Creek belong here, and that the zone ends against the Glasgow fault.‡

This latter fault enters the Reefton Subdivision near the great bend in the Buller, and is readily traced as far south as Flaxbush Creek. Southward, although the sections along Ram and Dee creeks are good, no sign of faulting that could be referred to this line was observed. The downshift of the earth-block that forms the Inangahua-Grey valley is apparently transferred to a great fracture which separates Boundary

* N.Z. G.S. Bull. No. 13, 1911, p. 47. † *Ibid.*, p. 45. ‡ N.Z. G.S. Bull. No. 17. 1915, p. 63.

Peak from the rest of the Brunner Range. This dislocation, which may be termed the Boundary Peak fault, is easily traced as far south as Landing Creek as a double fracture, with about half a mile between the breaks. The zone, which has a south-south-west course, is interrupted by an important series of south-east-striking fractures, but is quite possibly represented farther south by irregular minor faults that occur in the ancient rocks close to the junction of the Tertiaries with the Palæozoic sediments.

The south-east-striking fault-zone mentioned above as consisting of several sub-parallel fractures runs from Larry Creek to the Waitahu Forks, leaving the subdivision by way of the wide valley of the south branch of that river. Southward and south-westward of this earth-rupture lies the relatively depressed and intensely faulted area forming the Reefton hills, which to the eastward is bounded by two lines of dislocation that flank the western bases of Mount Albert and Mount Gore respectively, and pass northward and southward beyond the limits of the area described.

The Tertiary faults of the Reefton hills, although they cannot be compared in point of length or magnitude of throw with the major Tertiary faults which have just been described, are of great economic interest in that some of them shatter or displace the auriferous lodes of that district. They may be grouped into several well-marked systems, but in such an intensely faulted area there is a tendency for the fractures produced by the later stresses to follow previously existing planes of rupture.

The most important system—or rather zone, for its length is many times its breadth—is that of which some of the fault-planes cross the head of Murray Creek, from which fact it may be termed the Murray Creek fault-zone. It has been traced from Boatman Creek to the Snowy River, a distance of over fifteen miles, while the breadth is rarely more than two miles. The strike is about N. 11° E., or parallel with the pre-Tertiary Reefton zones; indeed, the Murray Creek zone lies immediately to the east of the eastern run of lodes, and may be considered to represent a reopening along one edge of this old fault-belt. The Miocene rocks are deeply involved in this belt of dislocation, and along it also occur Devonian rocks.

Another important system of faults, which may be called the Black's Point system, from the powerful fault near that township, and of which most of the members have an east-north-easterly trend, has representatives as far south as Merrijigs. Closely connected with these faults, and crossing them nearly at right angles, are the faults that control the course of the upper tributaries of Devil Creek. This system of faults and their transversals have had a most detrimental effect on the exploitation of the auriferous lodes of the area they traverse.

The third, or Blackwater, fault-system is considered to be formed of fractures subsidiary to the great Boundary Peak fault, which probably passes somewhat to the westward of Blackwater Township, its course now being concealed by the Recent gravels of the Grey Valley. The individual fracture-planes strike about N. 12° W., while the general course of the zone is about north-north-east.

STRUCTURE.

The Reefton Subdivision forms part of a much larger area in Westland and Nelson lying to the west of the Alpine chain. Bulletins Nos. 1, 3, 6, 11, 13, and 17 (New Series) deal with portions of this area, but still its greater part has not received detailed examination. The labours of the staff of the old Geological Survey, and in particular those of Mr. A. McKay, have shown that the main structural features are everywhere similar. Briefly, the Reefton Subdivision consists of earth-blocks which by differential elevation form the uplifted blocks of the Paparoa and Victoria ranges, the trough of the Inangahua-Grey valley, and the shelf-like blocks intermediate in height that constitute the Reefton, Orikaka, and Brighton uplands. The great dislocations that traverse the subdivision and separate the earth-blocks one from another have been described, and a brief account of the major structural units may now be given.

Victoria Horst.

The Victoria horst,* of which a portion forms the eastern part of the subdivision, consists of a number of elongated earth-blocks separated by fractures with north-north-east strike. That the various blocks comprising the horst were not elevated equally is undoubted, although where such major features are concerned the area examined is too small to furnish enough data to prove this quantitatively. The heights, 4,600 ft. and 4,635 ft., of mounts Curtis and Wynn, the highest points of the Brunner Range, may be compared with 4,081 ft. and 4,247 ft. heights on the Kirwan Range, and also with Mount Albert 5,069 ft., and Mount Ross 4,996 ft., peaks on the most westerly ridge of Victoria Range proper. The general trend of the western edge of the elevated area is nearly north and south, while the major faults run about north-north-east. It follows that the southern ends of several blocks in turn form the edge of the horst, and it is characteristic of each earth-block that it decreases in height as this edge is approached. Thus the Lyell block drops from Mount Lyell, 3,549 ft., to Trigonometrical Station H, 2,525 ft.; the Brunner block from Mount Wynn, 4,635 ft., to Bourke's Rock, 4,282 ft., and again to Conical Hill, 3,480 ft.; and the Mount Albert block from Mount Ross, 4,996 ft., to Bald Hill, 3,898 ft. A westward warp as well as this southward pitch is also probable on theoretical grounds. It is certain that faulting, cross or oblique, accompanied the southward tilt of each block, but this is not demonstrable except in the case of the Brunner and Kirwan blocks, the southward extensions of which have been let down by a south-east-striking fault-zone and now form the Reefton hills or the Reefton shelf.

Paparoa Horst.

The structure of the Paparoa horst is very similar to that of the Victoria horst, but as the whole of this structural unit has been examined in detail it is possible to interpret the features it presents with more confidence. Like the Victoria horst, it consists of a number of earth-blocks, each possessing a length of many times its breadth, and separated by vast north-north-east-striking diaclases.† This inevitably suggests the existence of cross-fractures similar to those occurring in the Buller-Mokihinui Subdivision. The positive geological data necessary to prove the existence of such faults is of the most meagre description, but on physiographical grounds the writer regards the statement as proved in regard to several of the blocks. Thus it is argued that a great fracture crosses the Paparoa Range in an east-south-east direction by way of the upper Waitakere valley, which is characterized by few outcrops and vast screes. It enters the Otututu basin along Morison Creek, a stream with a straight valley and few outcrops, and from its crush-belt may come the enormous slip which overburdens the Otututu below the junction of the Morison. To its presence may be attributed the abrupt southern scarp of Mount Raoulia, and the difference of height between mounts Epping and Beeche, Mount Micawber and The Pinnacle, mounts Faraday and Priestley.

* According to Suess (" Das Antlitz der Erde," English translation, vol. i, 1904, p. 126), to whom the term is due, a horst is a ridge left between two areas of subsidence or graben. As will be subsequently brought out, the writer believes that the mountain-blocks of the Reefton Subdivision owe their elevation to direct uplift above, and not to the subsidence of, the adjacent areas. Thus it is doubtful if the use of the words horst and graben as applied to the earth-features here described is justifiable. The terms, however, have been freely used by various writers to describe similar features, and are therefore retained in the present publication.

† A term suggested by Daubrée to designate large fractures not accompanied by much relative movement.

The width of the granite rocks which here form the range is decidedly greater north of this hypothetical fault than it is south of it. This implies a relative depression of the southern portion of the range, and, as has already been stated, this is supported by the topography. It is probable that other subsidiary faults exist in this locality, but the evidence for their occurrence is even more meagre than that detailed. It may be mentioned that this part of the range, though it contains peaks of higher average height than any other portion, yet offers the most practicable route through these mountains between the Buller and Brunner gorges, in both of which localities the geological maps of Bulletins Nos. 17 and 13 show series of cross-faults.

The principal mass of the Paparoa Mountains consists of a great earth-prism, of which a length of about twenty-nine miles lies within the subdivision, with a width of about eight and ten miles respectively on the southern and northern boundaries of the area described. On the west the marginal dislocation is the Lower Buller fault; on the east, the great zone of fracture that, crossing from the Blackwater, traverses the upper valleys of the Te Wharau and Whitefoord, reaches the edge of the range north of the gorge of the Otututu, and from thence defines its eastern flank southward beyond the subdivision. The main prism is cut up into numerous smaller prisms by the longitudinal and transverse fractures that have already been described. The assemblage of earth-blocks has been elevated as a whole, although the separate blocks have each their individual pitch and tilt. Clinging to the main prism of the range are subsidiary blocks, of which the most important is that of which the southern end forms Mount Raoulia (4,400 ft.). Heights lower but of a similar order are maintained for ten miles northward, but beyond this the height decreases — that is, the block pitches to the northward until it finally is covered by Tertiary strata and merges into the Orikaka uplands. Another subsidiary block of much less elevation lies against the range in the Waiwhero Survey District. Its southern toe reaches the township of Barrytown, while northward it extends beyond the Punakaiki. Even here, however, its northern pitch has greatly reduced the height of the crests, while still farther north it is masked by Tertiary rocks, and finally merges into the Brighton plateau.

Inangahua-Grey Graben.

This great depression occupies a large area in the subdivision, and extends meridionally from one boundary to the other. A graben as commonly defined is an earth-trough, with a length of many times its width, that is separated by two great dislocations, one on either side, from the neighbouring earth-blocks, between which it has been let down. The Inangahua-Grey depression does not entirely conform with this definition, in that the limiting fractures are neither simple nor belong throughout even to the same zones of dislocation. It may be considered as a structure in which the cross-section shows step-faulting on either side of the block most deeply foundered, and in which the whole series of blocks pitches southward, while gravel-deposits have filled it to a particular contour. Thus the depression widens southward in a series of steps the distinctness of which depends on the amount of throw of the bounding faults, the warp of the intervening blocks, and the amount of denudation they have suffered before the deposition of the masking gravels. The graben, as here considered, is a feature difficult to define, which owes its existence primarily to diastrophic movements, but which has since been greatly modified by denudation and deposition. It cannot be doubted but that beneath the gravels and Late Tertiary beds which floor the depression earth-blocks exist comparable in size and structure with those that form the horsts, although from analogy with the intermediate shelves, to be presently described, the faulting will be much less pronounced. This is strongly supported by the fact that faults may be traced in the northern portion of the trough. In the southern portion, however, the data so far collected are too meagre to permit of a statement more positive than that such an hypothesis is not contradicted.

The graben crosses the northern boundary of the subdivision with a width of about one mile, which at Inangahua Junction has increased to over four by the southward pitch of what may be termed the Lyell block, and is still further augmented southward as other blocks involved by the Boundary Peak fault are covered by the gravels of the lowlands. At Reefton the trough is fully six miles across, but southward it contracts somewhat by the injutting of a block of greywacke from the eastward. At Hukarere, however, the width has nearly doubled by the abrupt disappearance of the Mount Raoulia earth-block that as far as Hinau had formed the western boundary of the trough. Even before the Big River is reached the gravels begin to encroach on the gently southward tilting earth-block that forms the Reefton uplands. South of Snowy River this is entirely hidden, and the graben loses its trough-like character in the wide terraced lowlands of the Ahaura and Arnold rivers, which in turn merge into the coastal plain of North Westland.

Reefton Plateau.

This great shelf, intermediate in position between the Victoria horst and the Inangahua-Grey graben, occupies a large part of the Reefton and Waitahu survey districts. It is bounded by faults on all sides save to the southward, in which direction it disappears beneath Recent gravel-deposits. Innumerable fault-planes traverse it in many directions ; within it, in fact, lie the most intensely faulted regions of the subdivision. The whole shelf may be considered as consisting of down-faulted portions of the Brunner and Kirwan earth-blocks, a supposition strengthened by the fact that it is divided by a meridionally disposed belt of dislocation—the Murray Creek fault-zone—in line with the fracture separating the above-mentioned ranges. Of these divisions, the eastern lies at a decidedly higher elevation than the western. At one time probably the whole shelf was covered with Miocene beds, but now only fault-involved fragments remain upon the readily denuded western portion. On the eastern portion, however, a large area of coal-measures in horizontal attitude still exists.

Orikaka Plateau.

Only a small part of this physiographic element, which is regarded as a deformed plateau, is within the subdivision, and this portion is probably the northern down-pitched end of the Mount Raoulia earth-block. Much of it is covered by Tertiary beds, and in this respect is analogous to its major northern part which Morgan and Bartrum* regard as "a distorted plateau, consisting of granite, gneiss, and Palæozoic sedimentary rocks capped in most places by Tertiary coal-measures." For a fuller description of this physiographical unit, and for details concerning the fractures that traverse it, the reader is referred to the text and maps of the above-quoted publication.

Brighton Plateau.

The Brighton plateau-shelf is more regular by far than those already described. It is ten miles wide on the northern boundary of the subdivision, and this width is maintained to the Punakaiki River, a distance of eighteen miles, south of which point it gradually narrows, and finally wedges out a little north of Barrytown. On the east

* N.Z. G.S. Bull. No. 17, 1915, p. 48.


Fig. 1


Fig 2.


Fig. 3


Fig. 4.

Plate VI.—Fig. 1. Crest of Mount Albert (5,069 ft.) in November. Fig. 2. Victoria Range Eastward from Mount Albert. Fig. 3. Paparoa Range in Winter (the hills between the Mawheraiti and Inangahua rivers are in the middle distance, and the Inangahua flood-plain in the foreground). Fig. 4. A Mountain Stream (Giles Creek).

[Face p. 65

the block is bounded by the Lower Buller fault, which towards the south disturbs the strata for some distance from the principal fracture. The main portion of the block, however, is remarkably free from decided deformations. The fault that crosses the Punakaiki just below its gorge appears to die out northward, or perhaps is continued as a zone of strain in the limestone, marked by caves and underground watercourses. It is along this and another zone of strain or incipient fracture, lying about a mile and a half to the westward, that the depression described on a previous page* occurs. The Miocene strata which cap this block dip gently eastward, and the disappearance of the resistant middle beds beneath the weak upper layers has no doubt in part determined the position of this piedmont depression. This is the explanation of the feature evidently relied on, although not expressly stated, by Bartrum in his paper "The Geological History of the Westport–Charleston High-level Terraces,"† but the limestone cliffs that fringe its western edge at many places are not thereby adequately accounted for.

The western edge of the Brighton block is also undoubtedly limited by a line of dislocation, which is probably comparable to the Lower Buller fracture. Minor faults belonging to this zone were observed north of St. Kilda and near the mouth of the Fox River, and again at Limestone Creek. The general straightness of the coast-line north of Cave Point, and its parallelism with the course of the great fractures of the subdivision, strongly support this view. Southward of the Punakaiki, where the resistant limestone disappears, the trend of the coast changes; but this alteration is readily explained by the gentle southerly pitch of the block bringing the weak upper beds of the Miocene to sea-level, and exposing them to marine erosion. It should be noted that the trend of the coast again alters as soon as Maukurunui Bluff is reached, where the hard greywacke of the Paparoa Range first reaches the shore. That such an elongated earth-block should be free from cross-faulting is remarkable, but no evidence of transverse fractures could be found. The structure is further described on a later page, where it is pointed out that the block is characterized by an undulatory structure along its length, together with a southward pitch and eastward tilt.

SCENERY IN RELATION TO STRUCTURAL FEATURES.

In the Reefton Subdivision the major elements of the scenery are determined by the underlying structure. Thus the mountains and the hill country have been sculptured from great earth-blocks, while the lowlands are formed of gravels that mask still others. To this structure the ranges owe the straightness of their base-lines, the abrupt convexity of their flanks, and the height-equality of their ridges, while the progressive drop of the tops of hill groups is controlled by the same cause. Subaerial denudation acting through long years upon rocks differing greatly in nature and attitude has produced a great diversity of land-form. The massive prisms of granite from which some of the mountain-blocks have been carved wear down into long roof-like ridges, that break into separate pyramids and later form insecurely piled rock spires. Gneiss, again, produces at first elongated asymmetrical dome-shaped masses, from which in process of time are sculptured fantastic pinnacles and savage crags. The greywackes form irregular mountains of far gentler outline, while the grits and conglomerates of the coal-measures give rise to great precipices, of which that facing the upper valley of the Punakaiki is the best example. The calcareous strata produce land-forms which vary with the attitude of the rock. The highly tilted beds give steep slopes, the moderately inclined long escarpments, and the gently dipping and hori-

* See p. 42. † Trans., vol. xlvi, 1914, pp. 255–262.

zontally disposed have produced the narrow cañons and stupendous cliffs of the coastal region. Other Tertiary rocks are of so weak a nature that they have been either entirely planed down or cut into hilly labyrinths of low elevation. In spite of the great variety of detail thus introduced into the landscape, and the fact that all but the mountain-crests are covered by luxuriant vegetation, the monotony and harsh lines of the major features tend to produce weariness even for the most splendid scenery the district can offer.

The effects of the local glaciation, which has everywhere modified the forms of the highest mountains, have not hitherto been considered. This factor has had a most powerful influence in fashioning the great peak precipices and serrate ridges which abound in both the Victoria and Paparoa ranges. It seems probable that the head-wall recession of the many cirques, with formation of cliffs, which in the subdivision are rivalled only by fault-line scarps and sea-cliffs, has been aided by the natural jointing of the thick gneissic layers. Such a structure must have added to the quarrying-power of the frost. Certain it is that gneissic peaks are far more sharp and grotesque in profile than the granite peaks of corresponding height, and it is probable that this great variation in form can have been caused only by the difference of internal rock-structure being brought out and exaggerated by glacial denudation.

The traveller entering the Inangahua valley by way of the Buller Gorge or by the equally beautiful but less-known Lyell Gorge has long been confined within narrow walls, and is relieved by the wide view of wooded lowlands backed by the far-stretching mountain rampart. At his feet the brown flood of the Inangahua swings through boulder beaches that, glittering snow-white in the sun, contrast strikingly with the swirling foam-flecked waters of the river. As he proceeds southwards the combinations of the elements that make up the foreground are soon exhausted, while the mountain-wall ever preserves its integrity. No dominant peak towers above its fellows, and the sense of height is lost even before the range begins to recede from the observer. Near the Landing Bridge the Paparoas come into view, and as they lie nearer at hand their crest is less monotonous than that of the eastern range. If the light fall suitably each valley may be picked out, and half-way up their green flanks may be traced a line of semi-detached hills that are sculptured from a rock-plate separated by a fracture-zone from the main range. As one proceeds southward the bare terraces seen from Fern Flat bring a welcome change of foreground, but this type of scenery is better exemplified in the valley of the Mawheraiti. But here also the mountain background, though by no means so regular as in the Inangahua basin, soon brings weariness by reason of the harsh abruptness of the lines in which it rises from the lowlands, and the total absence of the sweeping catenary curves so pleasing and restful to the eye.

A well-graded saddle-track winding through luxuriant beech forest gives easy access to the summit of Kirwan's Hill. From this coign of vantage the wide lower valley of the Inangahua lies spread out as on a map. The Paparoas, the crests of which are at nearly the same height as the observer, take on the appearance of rocky upland-downs, above which the rugged mass of Mount Uriah alone rises. To the eastward a sea of bare broken peaks fills the field of view, while on the far horizon the Spenser Range breaks in a line of snowy foam. The metaphor is singularly appropriate, for no great mountain-mass stands pre-eminent above its fellows, and all are equal—enormous rock-waves frozen at the instant of their extremest turbulence. In summer the greys and buffs of the crags, the yellows and russets of the alpine meadows, and the dull greens of the climbing forest blend in one harmonious whole. In winter icy winds sweep over the mountains, which shiver beneath snow-mantles that reach far down their shoulders.

[*Photo by W. Sherlock.*

PLATE VII.—INTERMONTANE VALLEY OF THE INANGAHUA RIVER.

Face p. 67.]

Other aspects of the high country are presented from the intermontane valleys, each of which has a charm of its own. The easily accessible Inangahua is in many ways typical of all, and shows innumerable combinations of boulder-strewn river-bed and native bush backed by great rock precipices and pyramidal peaks. In the Waitahu the vertical sandstone cliffs of coal-measures rising high above the shaggy forest of the middle valley give variety. Larry Creek, in a succession of rapids and rock-bound pools of limpid emerald-tinted water, before reaching the lowlands plunges through a narrow gorge deeply cut in solid granite. Perhaps the finest scenery of all is to be found in the upper Otututu and the Gordon, where the valley-walls are ice-worn cliffs topped by fantastic mountain-crests. Another type of river scenery is furnished by the limestone cañons of the coastal streams. As one travels from the coast up the Fox the white ramparts, at first widely flared, slowly approach until there is barely room for river and track between the towering cliffs. Above the lower forks the fissure contracts still more, so that no track can be maintained, and the stream swings from one great wall to the other. It is here, where distance can blur no detail, that the architectural effect is most marked. Each course of the well-bedded rock is plainly shown; the wall swells gently forward between widely spaced minor joints, while the regular major joint-planes are marked by incurving alcoves roofed by symmetrical domes, enriched with many quaint designs of beaded mouldings, the gift of the slow-falling drops. Soon the Paparoas come into the narrow field of view, and the traveller sees through a vista of bush-crowned cliffs the most rugged mountains of the range stand sharp against the sky.

That portion of the Buller Gorge within the subdivision owes its chief charm to the river having cut its way through a similar area of limestone. The scene is here enhanced by the broad hurrying flood, of which the very width dwarfs the heights of the bluffs even where these drop sheer to the water's edge.

The nature of the scenery of the shore-line may be inferred from the descriptions already given. The hard Early Tertiary conglomerate that forms the land-margin in the south of the subdivision has produced massive vertical cliffs. Numerous fantastic stacks—the Motukiakia Islands—rise from the rock platform cut by the waves that at high tide sweep the base of the main cliff. In sharp contrast with the naked faces just mentioned are the steep hillsides clothed with matted scrub that next succeed, and indicate the underlying greywacke. Where limestone and calcareous sandstone form the coast the chief interest of the scenery is due to the architectural effects, which in turn are controlled by the horizontal bedding of the rocks. Layers differing in resisting-power alternate, so that the appearance of coursed masonry in infinitely varied design characterizes the cliffs. In close proximity to the artificial-looking walls occur bold savage headlands of granite and gneiss, continued seaward by rock pinnacles and reefs half-awash. Between the capes are little coves, where gravel is ground to sand by the rhythmic swing of waves that, fresh from the Southern Ocean, here take the land

CHAPTER V.

GENERAL GEOLOGY.

OUTLINE OF GEOLOGY.

The Reefton Subdivision forms part of the foreland that resisted the great thrust from the south-east that produced the Southern Alps. This foreland includes that portion of Nelson lying to the west of the Alpine chain, an area that stretches into Westland as far south as the Mikonui Subdivision. Probably also the plutonic complex of western Otago, with its local areas of Palæozoic sediments, forms a part, the intervening portion being represented by small unfoundered areas, of which that near Lake Mapourika is typical.

The oldest rocks of the subdivision are sharply folded greywackes and argillites, which contain no fossils, and of which the exact age is therefore uncertain. There is, however, little doubt but that they underlie quartzites, shales, and limestones containing fossils that prove a Devonian age. The greywackes and argillites may therefore be classed as Silurian or Ordovician, and perhaps beds of both ages go to make up the vast thickness of unfossiliferous beds here represented. The Devonian and pre-Devonian beds form a well-marked group, differing from all the other rocks of the subdivision in that they alone have been strongly folded. The greywackes and argillites may be correlated with the Kanieri Series* of Bulletin No. 1, with the Greenland Series of Bulletins Nos. 6 and 13, and with the Aorere Series of Bulletins Nos. 3, 11, and 17.

As is the case in the areas described in the above-mentioned bulletins, these rocks in the Reefton Subdivision have been intruded by granitic rocks which have been laid bare by denudation, and now occupy great areas, especially in the highlands. Younger

* The Kanieri Series of Hutton, Hector, and McKay is a totally different formation of Miocene age. The name, of course, has priority in this connection.

than the acidic rocks are innumerable auriferous - quartz lodes which have been extensively mined near Reefton, and from the degradation of which most of the alluvial gold of the subdivision has been derived.

Tertiary strata are well represented in the area under review by rocks of Eocene age, and again by great deposits ranging from the Miocene into the Pliocene. Later still are gravels—marine, glacial, and fluviatile—which overlie all older rocks unconformably, and bring the geological record down to the present day.

AORERE SERIES.

Distribution.

The rocks of the Aorere (or Greenland) Series cover 226 square miles in the Reefton Subdivision. They are exposed in two large blocks, in connection with each of which are several small detached areas. There is little doubt from their distribution that at one time the subdivision formed a portion of a much larger province over which these rocks were deposited, a province that in effect coincides with the west Nelson foreland mentioned above.

The largest continuous area of Aorere rocks is developed along the eastern edge of the Inangahua-Grey graben. It commences as a narrow wedge at Rough Stream (Inangahua Survey District), while south of Larry Creek it swells out to a breadth of five miles, a width maintained until the formation is hidden by the gravels of the Big Grey. Over this area occur patches of Devonian and Miocene rocks, often of considerable size, and in it occur granitic bosses irregularly disclosed by denudation. South of the Big Grey, Aorere strata outcrop in the Clarke River, and again appear at Bell Hill, fifteen miles south of the subdivision, an occurrence that links them with the isolated patches noted on the flanks of the Hohonu Range.* Northward along the Brunner Range are two small areas, the one at the head of Flaxbush Creek and the other forming part of the point of land at the great bend of the Buller, both of which are portions of the larger mass of these rocks in which the quartz veins of Lyell and New creeks occur. Closely connected with these and the greywackes of the Orikaka basin is a small patch of Palæozoic sediments that outcrops along the Buller below Inangahua Junction, and extends some distance up Welshman Creek. This may be considered a roof-pendant of the vast batholith on which it rests.

The other large area of Aorere rocks forms the southern end of the Paparoa Range, so far as these mountains are developed within the subdivision. The rocks here are a direct continuation of the Greenland beds of the Greymouth Subdivision. The small patch of greywacke lying in the basin of Dilemma Creek, a branch of the Fox River, must be regarded as a fragment, protected from denudation by involvement in the Lower Buller fault-zone. Probably the greywacke rubble noted in the upper valley of the Waitakere has been derived from a patch with a similar origin.

Structure.

Everywhere the rocks of the Aorere Series stand at high angles, and the writer knows of no large area of these beds that has not been affected by powerful faults. The strata always seem to have been in the zone of fracture, and the folding which has undoubtedly taken place has been to such an extent accompanied by contemporaneous fracturing, and further complicated by later faulting, as to render the determination of the direction of the foldings a matter of extreme difficulty. In the

* N.Z. G.S. Bull. No. 13, 1911, p. 49, and map of Hohonu Survey District.

area flanking the Brunner-Victoria Range, if the strikes and dips in the intensely faulted Reefton zones and in the immediate proximity of other powerful dislocations be ignored, the strikes as a whole vary between 10° and 25° east of north, while the dips are preponderatingly westerly. These rocks, however, in the narrow strip that forms the northern portion of the exposure, have a strike of 10° west of north and an easterly dip. The writer suggests that the original plication in this portion of the subdivision was in the form of a great monoclinal flexure striking about 15° east of north. The Palæozoic strata of the Paparoa Range exhibit strikes approximately at right angles to those of the beds of the Reefton area, the strike of disturbed rocks near fault-zones being ignored. Near the southern boundary of the subdivision a strike of 60° west of north, with a northerly dip, is predominant, while farther north the strikes vary greatly, but are generally west of north, although to a smaller amount.

Stratigraphical Succession and Conditions of Deposition.

The rocks of this great series consist chiefly of medium-grained greywacke. Coarser layers deserving the name of grit are quite rare, but fine greywacke grading into argillite is common, and forms thin beds, locally called "slate," separating the massive layers of coarser material or "sandstone." In the Reefton area the argillite bands are most prominent along the western portion of the hills, a distribution suggesting that the upper strata were, on the whole, laid down in quieter or deeper water than the lower. This conforms with the observations of Morgan* in respect to the rocks at Mount Greenland, near Ross. Again, in a general way what may be termed the Paparoa area contains decidedly fewer argillaceous members than even the lower beds of the Reefton area. This indicates that the land area that supplied the spoil lay to the westward.

The nature of the rocks, the complete absence of fossils, the alternation of beds of fine and coarse material, and the occurrence of ripple-marks in the greywacke indicate that deposition took place in fairly shallow water, and that the supply of waste was abundant. The fact that the alternation of argillite and greywacke is sometimes rapid suggests water shallow enough to permit of the loose deposits on the sea-bottom being readily agitated by the waves. The sorting of the waste was not perfect; thus even in the rocks formed of the coarser material argillaceous matter is present. All these facts are most readily explained on the assumption that the beds were laid down under off-shore conditions, and that the loose material, as a whole, had not travelled along the coast far enough to be well sorted. Further, the great thickness of these rocks implies the presence of a large land-mass.

Petrology.

The petrological nature of these rocks has already been adequately discussed by Bell and Fraser,† and Morgan,‡ and for a description of the various rock-types the reader is referred to their reports. As in the North Westland Division, the rocks are scarcely affected by regional metamorphism, while the aureole around the granite stocks is nowhere more than a quarter of a mile in width, and generally much less. The rock next the granite is usually quartz-mica hornfels, though variety is occasionally introduced by the occurrence of cordierite. Knotted schist is developed farther from the contact, and this grades into micaceous greywacke and argillite, and finally into the ordinary rocks of the series, normal in character save for a slight induration.

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* N.Z. G.S. Bull. No. 6, 1908, p. 98. † N.Z. G.S. Bull. No. 1, 1906, p. 46. ‡ N.Z. G.S. Bull. No. 6, 1908, p. 97 *et seq.*

The chemical composition of the rocks is as under, analyses from Bulletin No. 6 being inserted for comparison :—

——	(1.)	(2.)	(3.)	(4.)	(5.)	(6.)	(7.)
Silica (SiO_2)	74·91	71·80	70·81	67·90	55·80	53·59	51·43
Titanium dioxide (TiO_2) ..	0·88	0·60	0·58	0·98	0·89	1·10	0·95
Alumina (Al_2O_3)	10·16	12·54	12·53	14·62	21·79	21·95	20·37
Ferric oxide (Fe_2O_3)	2·18	0·48	nil	1·95	1·04	3·58	2·32
Ferrous oxide (FeO)	2·74	4·12	5·18	2·16	6·26	4·97	5·94
Manganous oxide (MnO) ..	0·05	0·25	0·62	0·02	0·20	0·04	0·04
Lime (CaO)	0·83	3·51	1·96	0·55	0·25	0·13	0·41
Magnesia (MaO)	1·38	2·28	2·84	1·32	4·57	2·86	2·77
Potash (K_2O)	2·24	2·27	4·31	4·07	4·96	5·64	6·40
Soda (Na_2O)	1·38	1·17	0·10	0·64	1·15	0·63	0·53
Phosphoric anhydride (P_2O_5) ..	0·19	0·18	n.d.	0·35	0·15	0·15	0·08
Sulphur trioxide (SO_3)	0·07	0·28	n.d.	n.d.	0·10	0·12	0·26
Carbon dioxide (CO_2)	0·89	0·05	0·10	0·38	nil	nil	5·88
Water below 100° C.	0·19	0·25	0·77	0·13	0·25	0·41	0·11
Combined water and organic matter	1·94	0·55		2·41	2·91	5·06	3·05
Iron as pyrites (Fe)	..	..	..	1·21	..	..	..
Sulphur as pyrites (S)	..	..	..	1·08	..	..	..
Arsenic as pyrites (As)	..	..	..	0·72	..	..	..
Totals	100·03	100·33	99·80	100·49	100·32	100·23	100·54

(1.) Greywacke near junction of Boatman and Topfer creeks.
(2.) Micaceous greywacke (highly altered) from Waitaha Sugarloaf.
(3.) Micaceous greywacke from Flat Creek, Mount Rangitoto.
(4.) Country rock, Blackwater Mine, altered by metasomatism.
(5.) Argillite from Cedar Creek Track.
(6.) Argillite near junction of Boatman and Topfer creeks.
(7.) Country rock, Garden Gully, altered by metasomatism.
Nos. (2), (3), and (5) quoted from Bulletin No. 6 (New Series), page 101.

Age and Correlation.

Von Haast* was the first geologist to examine the rocks of this series, which he observed near the Big Grey - Alexander junction, and again at Maukurunui Point, on the coast-line. In Hochstetter and Petermann's atlas of New Zealand† the map of the Province of Nelson, in great part compiled from information obtained by von Haast, shows these rocks as belonging to the Trias-Jura. All writers are agreed in correlating the Reefton greywacke and argillite with the similar rocks of the Paparoa Range and Mount Greenland, but when beds farther afield are considered differences of opinion prevail. Cox‡ and McKay§ placed them in the Carboniferous, and correlated them with the Maitai rocks of Nelson and the Alpine chain. Park maps them as from Carboniferous to Ordovician, but states that " there is nothing to show that they do not belong to the great Hokonui System of Permo-Jurassic age."|| He seems, however, to favour a

* Haast, Julius von : " Report of a Topographical and Geological Exploration of the Western Districts of the Nelson Province, New Zealand," 1861, pp. 101, 107, and 108.

† Hochstetter, F. von, and Petermann, A. : " Geological and Topographical Atlas of New Zealand," 1864, tafel 6.

‡ Cox, S. Herbert : " Report on Westland District." Rep. Geol. Explor. during 1874–76, No. 9, 1877, p. 77.

§ McKay, Alex. : " On the Geology of the Reefton District." Rep. Geol. Explor. during 1882, No. 15, 1883, p. 131.

|| Park, James : " The Geology of New Zealand," 1910, pp. 81, 371.

Silurian age. Marshall* also places this great series in his Maitai System, and maps it as Triassic. These correlations are all based on lithographical resemblances between the Reefton rocks and the Maitais, and not upon internal evidence. McKay reports the occurrence of the fossil annelid *Torlessia mackayi* in these strata at the Twelve-mile,† south of Barrytown, but the present writer could find no trace of this or any other fossil in any locality. Morgan,‡ in discussing the age of the Greenland rocks of the Mikonui and Greymouth§ subdivisions, and Morgan and Bartrum, in the case of the Buller-Mokihinui|| Subdivision, are strongly inclined to consider the strata as of Ordovician age. The present writer believes the rocks to be pre-Devonian in age, and on a later page will set forth the reason for this opinion.

It must also be pointed out that although the sequence of these rocks resembles that of the strata of the main ranges of New Zealand, and the rocks themselves are similar in a general way, there are some lithological differences. These, though plain enough to the eye, are not easy to describe. The unaltered rocks of Reefton district are characterized by a rather greener tint, and are decidedly less prone to weathering than those of say, Wellington, and this is especially the case along the shore-line. Again, where the beds have been strongly faulted the greater abundance of carbonaceous material in the Maitai rocks is manifested by a decidedly greater prominence of graphitic surfaces. The rocks are, so far as chemical composition goes, very similar to those of the Wellington District, as may be ascertained by comparison with the analyses below. The chief differences appear to lie in the decidedly higher soda-content and slightly higher iron-content of the Wellington rocks, combined with lower potash and magnesia percentages.

——	(1.)	(2.)	(3.)	(4.)	(5.)
Silica (SiO_2)	70·75	70·20	66·10	58·70	57·89
Titanium dioxide (TiO_2)	0·62	0·66	1·50	0·93	1·00
Alumina (Al_2O_3)	12·30	13·53	14·55	18·29	19·03
Ferric oxide (Fe_2O_3)	2·72	1·68	0·40	1·99	4·48
Ferrous oxide (FeO)	2·74	3·24	4·20	6·03	2·88
Manganous oxide (MnO)	0·06	n.d.	0·25	n.d.	0·04
Lime (CaO)	1·90	1·80	2·95	1·30	0·16
Magnesia (MgO)	1·22	1·48	0·30	2·96	1·47
Potash (K_2O)	2·48	3·18	1·07	3·30	4·21
Soda (Na_2O)	3·18	2·04	3·25	2·63	2·02
Phosphoric anhydride (P_2O_5) ..	0·16	n.d.	0·37	n.d.	0·26
Sulphur trioxide (SO_3)	0·18	n.d.	0·34	n.d.	0·11
Carbon dioxide (CO_2)	nil	n.d.	0·43	n.d.	nil
Water below 100° C.	0·16	n.d.	0·80	n.d.	1·15
Ignition loss	1·79	2·03	2·71	4·11	5·65
Totals	100·26	99·84	99·22	100·24	100·35

(1.) Greywacke, stone-quarry, Breaker Bay, Wellington Harbour.
(2.) Grey argillite, Red Rock Point, Cook Strait, near Wellington.
(3.) Greywacke, Tinakori North quarry, Wellington.
(4.) Green slate, Red Rock Point, near Wellington.
(5.) Argillite, Point Arthur, south of Muritai, Wellington Harbour.

* Marshall, P.: "Geology of New Zealand," 1912, p. 151; also "New Zealand and Adjacent Islands," 1912, p. 15. Reprinted from the "Handbuch der regionalen Geologie," 5 Heft (Band vii, Abtielung 1).

† McKay, A.: "On the Geology of the Reefton District, Inangahua County." Rep. Geol. Explor. during 1882, No. 15, 1883, p. 131.

‡ N.Z. G.S. Bull. No. 6, 1908, p. 69.

§ N.Z. G.S. Bull. No. 13, 1911, p. 49.

|| N.Z. G.S. Bull. No. 17, 1915, p. 68.

DEVONIAN SERIES.

Distribution and Structure.

Rocks of a Devonian age cover a very limited area in the Reefton Subdivision, in all three and a half square miles, and occur only in a zone of intensely faulted country from Boatman Creek to Big River. The largest area stretches from south of Boatman Creek to beyond Rainy Creek, a distance of eight miles, and has an average width of less than half a mile. A small area occurs at the head of Golden Lead Creek, but does not appear to reach the small branch of the Big River immediately to the south, although the rocks outcrop beyond the divide between the two streams. Connected with this patch is a narrow lens exposed along a fault in Willis Creek, and again on the Progress water-race just south of Deep Creek.

In structure the Devonian rocks resemble the older greywacke and argillite, in that the beds are always steeply dipping. No definite folds have been recognized, and the rocks are traversed by numerous faults.

Stratigraphical Succession and Conditions of Deposition.

The Devonian beds contain numerous lithological types—greywacke, argillite, shale, limestone, quartzite, and sandstone. Sections are fairly well exposed, and it would be thought that with such diverse rock-species no difficulty would be encountered in arriving at definite conclusions in regard to the succession of the beds and their thickness. Such, however, is not the case, for the many faults militate against precision and render difficult even the determination of the proper sequence. The lowest beds are exposed along the tracks leading from the Murray Creek saddle into the Waitahu valley. They consist of fine-grained pale-green argillite or shale which readily weathers to various shades of red, and occasionally contains bands of light-coloured greywacke. These grade upward through fine argillaceous sandstone into white even-grained quartzite, occasionally containing bands of argillite which stain the neighbouring beds a flesh colour. In another portion of the section here exposed the quartzite is seen to become calcareous, and finally passes into arenaceous limestone with a bed of pure coralline rock intercalated between its layers. The leaching by surface waters of the arenaceous limestone changes this rock into a pale buff-coloured, rather incoherent sandstone. In this section the thicknesses of the various beds are as follow: Lower argillite, 300 ft.; quartzite and calcareous sandstone, 300 ft.; arenaceous and coralline limestone, 600 ft. Another section along the north bank of the Inangahua shows at least 1,000 ft. of quartzite that passes upward through light-coloured siliceous shale into an impure limestone, which is followed by a structureless black mudstone and a layer of coralline limestone. Here the quartzite in its lower portion frequently contains irregular black markings, and is broken by several unimportant strike-faults. In Lankey Creek the quartzite is not nearly so thick; it grades downward into argillite and upward into limestone. Intercalated with it, in addition, is a bed of black structureless mudstone which contains much pyrite, from the decomposition of which iron and aluminium sulphates result, the rock being locally known as "alum shale." This band is at least 40 ft. thick, and in it are lenses of calcareous matter that are probably concretionary. The underlying rock consists of narrow bands of quartzite—say, an inch thick—separated by thin layers of black material apparently similar to the overlying "alum shale." Seemingly overlying the limestone of this locality are argillite and greywacke containing Devonian fossils, but otherwise indistinguishable from the beds of the Aorere Series so abundantly developed in the subdivision. This locality, however, is traversed by a powerful fault, and the true position and thickness of the rocks are matters of doubt. Similar argillite occurs in connection with the intensely faulted Devonian rocks of Rainy Creek, and since they are there in the same relative position it is probable that they are part of the general succession and overlie the limestone. At Rainy Creek also occurs the black structureless mudstone. On the ridge between Boatman Creek and the Waitahu the Devonian rocks seem to be represented only by quartzite, which also forms the main portion of the Golden Lead Creek area.

The diverse rock-types represented in the sequence, and their rapid alternation in some localities, show that the conditions of deposition quickly changed. This indicates accumulation close to an ancient short-line, a suggestion that finds support in the obvious lensoid shape of the beds. Again, it should be noted that the purest limestone layers are always largely coralline, and that the impure calcareous rocks consist of the remains of crinoids and shallow-water brachiopods mixed with sand. In the lower quartzite exposed along the north bank of the Inangahua the irregular carbonaceous streaks are certainly plant-remains, and the black carbonaceous mudstone and the layers of similar material interleaved with the quartzite of Lankey Creek probably represent the deposits of an ancient littoral lagoon. The argillite and greywacke overlying the limestone indicate off-shore conditions, but the incompleteness of the record in this part of the sequence does not permit of further speculation on this point. It is not known upon what beds the argillites and greywackes underlying the quartzite rest. These are decidedly tuffaceous in appearance, and perhaps are the equivalents in this locality of the Te Anau breccias and aphanitic sandstones of Hector, McKay, and Park.

The Relationship of the Devonian and Aorere Rocks.

The relationship of the Devonian and Aorere rocks is a matter of great economic as well as theoretical importance. For it is well known that metalliferous lodes when passing from one formation into another frequently change in character, or perhaps die out altogether. Concerning this point the Reefton district affords no evidence, since there is no known instance of a lode passing from the argillite and greywacke, that form the country of the quartz veins, into the beds of the Devonian Series. In fact, as McKay pointed out many years ago, no auriferous vein is known to occur in the Devonian strata at all. The possibility of these latter rocks underlying the lode-country can be regarded only with uneasiness by those interested in deep mining in the Reefton field. Again, the correct interpretation of the evidence presented in the Reefton hills will fix within narrow limits the age of the great rock-sequence termed in this report the Aorere Series. It is for these reasons that the reader's indulgence is craved for the lengthy argument that follows.

Hector* in 1873 made a cursory examination of some of the sections, and tentatively expressed the opinion that the Devonian rocks underlay the greywacke and argillite containing the auriferous lodes. Cox,† from observations made in 1875, considered that the Devonian strata passed unconformably beneath the auriferous series, which he correlated with the Maitai Series. Before this, however, in 1874, McKay‡ had arrived at the same conclusion. This geologist re-examined the sections with Cox in 1875 and again in 1882, and in his report of 1883§ elaborates his views and describes in considerable detail the sections on which he relied. In effect, he considers that the Devonian rocks outcrop along the crest of an irregular anticline

* Rep. Geol. Explor. during 1873–74, No. 8, 1877, pp. xiv, 86.

† Cox, S. Herbert: "Report on Westland District." Rep. Geol. Explor. during 1874–76, No. 9, 1877, pp. 74, 75.

‡ McKay, Alex.: "Reports relative to the Collections of Fossils made on the West Coast District, South Island." Rep. Geol. Explor. during 1873–74, No. 8, 1877, pp. 97 *et seq.*

§ McKay, Alex.: "On the Geology of the Reefton District." Rep. Geol. Explor. during 1882, No. 15, 1883, pp. 105 *et seq.*

which plunges both north and south, a structure that causes the disappearance of the fossiliferous rocks beneath those of the auriferous series. The present writer, on the other hand, believes that they are involved along a great fault-zone, and that depression has preserved from denudation these few remaining fragments of a once widespread sheet. The sections on which McKay relied to prove the superposition of the auriferous rocks usually afford doubtful evidence, in that the actual contact of the two formations was seen in one case only. On the other hand, they usually afford positive evidence of faulting. On these points, however, the following faithful descriptions by McKay may be allowed to speak for themselves. Thus, in describing the Rainy Creek section he states, "The coal-beds which cap both the auriferous and fossiliferous rock suddenly dip at a very high angle, forming a deep synclinal trough, obscuring what would otherwise have been the junction between the fossiliferous and northern division of the auriferous rocks which succeed the coal and dip away to the west"*; and again, in speaking of the same section, "it would seem that here there is an inversion of the Devonian beds."† In describing the section exposed along the right bank of the Inangahua River he states, "The junction to the east is obscured, but this rock [*i.e.*, grey quartzite] crops out close to the overlying sandstones and slates which form the eastern belt of auriferous country"‡; and again, in speaking of the western boundary of this section, "Parallel to this ridge [*i.e.*, of cherts and limestones], and on its western side, is a deep narrow valley, scooped out of the overlying slates [Devonian] and the rocks of the auriferous series, the junction of the two being apparently obscured by slope and creek deposits."§ Of the Lankey Creek section he says, "In the section across this portion of the Devonian belt the rocks are much disturbed, highly contorted, and often locally inverted"||; and again, "I got bearings of the two rocks [Devonian and auriferous series] within a chain of each other, but the absolute junction was obscured, it taking place in a gully."¶

In regard to the section at the head of Murray Creek, McKay's descriptions do not indicate faulting. The eastern edge of the section in the Waitahu is mentioned by McKay thus: "The southern side of this last ridge was succeeded by cherts, and here for half a mile the section was lost. Then up the river appeared the auriferous sandstones and silky slates dipping west, though at a very high angle."** McKay nowhere describes the western junction in this section of the Devonian with the auriferous series. Speaking in general of the eastern junction of the Devonian and auriferous rocks he says, "I could never get at the junction of the eastern auriferous rocks with the cherts east of the fossiliferous belt."†† From the above quotations it will be manifest that McKay relied on the general distribution and structure of the two series for his belief of the inferior position of the Devonian beds. At only one place—*i.e.*, Murray Creek—does he assert that the cherts come from beneath the auriferous rocks.††

The present writer has examined all the sections described by McKay, as well as others unknown at the time of his visit, and has found in every case that the junctions of the Devonian and Aorere rocks are either obscure or undoubted fault-planes. Thus the Rainy Creek section exposes less than 20 chains of steeply dipping Devonian beds, including also two fragments of Miocene rocks, and flanked on the west by vertical Miocene grits that in a few chains are followed by crushed greywacke. The

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* McKay, Alex.: "Reports relative to the Collection of Fossils made on the West Coast District, South Island." Rep. Geol. Explor. during 1873–74, No. 8, 1877, p. 91.

† McKay, Alex.: "On the Geology of the Reefton District, Inangahua County." Rep. Geol. Explor. during 1882, No. 15, 1883, p. 109. ‡ *Op. cit.*, p. 108. § *Op. cit.*, p. 109. || *Op. cit.*, p. 111.

¶ McKay, Alex: "Reports relative to the Collection of Fossils made on the West Coast District, South Island." Rep. Geol. Explor. during 1873–74, No. 8, 1877, p. 93. ** *Op. cit.*, p. 94. †† *Op. cit.*, p. 98.

other edge is obscure, and the first outcrop east of the Devonian rocks consists of shattered greywacke. In the Inangahua section, on the south bank of the river, the Devonian strata are well exposed along the Progress race, and here the actual junction shows crushed argillite apparently dipping under shattered quartzite. The western edge of the fossiliferous rocks is exposed in this section on both sides of the Inangahua, in Yorkie and Lankey creeks respectively, in both of which localities the formations are separated by a few feet of pug and shattered rock. The eastern edge on the north bank of the river is covered by old Quaternary gravels. In the Murray Creek section the quartzite is not shattered, but a wide zone of crushed rocks of the Aorere and Miocene series lies to the west. A road has been cut along the fault-zone, which is continuously exposed to the saddle a distance of about a mile, and, as a coal-seam is also involved, faulting is peculiarly obvious in this locality. On the left bank of the Waitahu, on the upper track, the eastern junction of the Devonian and Aorere beds is well shown, and is manifestly a fault-fissure filled with crushed rock and containing an intrusive dyke. No other junction was observed in the section cut by the Waitahu itself; but in Orlando Creek, a small stream heading towards Boatman Creek, a large fault-zone contains great boulders of Devonian limestone between walls of Aorere rocks. Associated with this fault is a diabase dyke similar to that mentioned above. With regard to the Devonian rocks exposed in the basin of Deep Creek, the adit driven by the Big River Company from the head of Golden Lead Creek to the shaft of their mine is partly in Devonian quartzite and partly in rocks of the Aorere Series. The junction is undoubtedly a vertical fault-plane, with much pug between the walls. The fragment of Devonian argillite outcropping on the Progress race south of Deep Creek is in contact with a diabase dyke, and the limestone in the eastern branch of Willis Creek is undoubtedly adjacent to a fault. Thus in every section across the junction between the Devonian and Aorere rocks the field evidence either definitely proves the existence of a fault or is obscure, and in no section is there evidence of a junction of deposition, concordant or otherwise. Thus it has been demonstrated that the premises underlying the conclusions of McKay are erroneous, and that they furnish no proof concerning the relative age of the two Palæozoic formations.

The main Devonian area occurs as a narrow strip separated from the Inangahua-Grey graben by a ridge of Aorere sediments. On the eastern side of the fossiliferous rocks is a similar ridge which separates them from a depressed area, floored with Miocene rocks, lying at the base of the Victoria Range. It is evident from the distribution of the Miocene patches that at one time a continuous sheet of these rocks existed over the whole of the Reefton uplands. Overlying the Devonian beds, and in part obscuring them, are areas of Miocene rocks, which are, however, nearly absent from the Aorere ridges bounding the fossiliferous rocks to the east and west. The areas of Devonian beds lying in the basin of Deep Creek are also associated with Miocene strata. It is obvious that during Late Tertiary times the general movement of the Miocene and associated Devonian blocks has been downward along the fracture-zone in respect to the Aorere rocks on either side. The peripheral faults of the fossiliferous Palæozoic beds are certainly older than the Miocene. Their general parallelism with the auriferous lodes, and the occurrence in them of the diabase dykes so commonly associated with the lodes, strongly supports the view that they originated from the stresses which found relief in the intrusion of the dykes or the formation of the lode-fissures. The underground workings in the mines have shown that the fault-planes occupied by both the dykes and the lodes are steep-dipping and normal. Now, the faults bounding the Devonian blocks are certainly steep-dipping, and it is a legitimate assumption that they also are normal. If this be admitted it follows that the Devonian blocks have had from the first a tendency to sink relatively to the Aorere blocks on either side.

In addition to the peripheral faults of the Devonian areas are others that traverse them, and again others that affect the rocks close at hand. In fact, the Devonians lie in a zone of crushed and intensely faulted strata. As already stated, there are some faults, of which both walls are of Aorere rocks, which yet have entangled in the fissure fragments of Devonian strata. Thus a strong fault crossing Deep Creek just below the old Cumberland battery has angular pieces of quartzite embedded in the pug. A fault showing in a recent slip on the right bank of the Waitahu, opposite the hut two miles down the river, from the point where the track from the Murray Creek saddle reaches the river-bed, contains not only Devonian quartzite but coaly matter of Miocene age. Another fault in this locality, 20 chains west of the last-mentioned, contains large blocks of Devonian limestone obviously fault-involved. This is in Orlando Creek, where, as already stated, they occur in close association with a diabase dyke. To this fault must also be assigned the huge boulders of limestone that cumber the bed of the Waitahu directly in the course of this fracture. It has been shown on an earlier page that many of the faults of the subdivision contain filling that has descended from a higher level, but not one was observed of which the gouge came from a lower horizon—that is, so far as is known, all the faults are normal. The origin of fault-filling is not a matter which seems to have received much attention from geologists; and the only occurrences in which the fault-filling has come from below are the so-called sandstone dykes that are specially prominent in California, where special circumstances, which are quite inapplicable to the Reefton Subdivision, have been invoked to explain the unusual phenomenon. The writer is unable to understand how in ordinary circumstances it is possible for broken material of any kind to be forced up from below along a fault-plane, a conception necessary if the Devonian strata underlie the Aorere rocks. Again, if such be the case, to explain the occurrence of fragments of Devonian and Miocene rocks in the same fault will require that during one period of movement material was forced up along the fault-plane, while during another period it migrated downward.

In many ways the structural parallelism of the Miocene and Devonian strata entangled in the faults of the subdivision is most striking. Thus in the faults of the Reefton Subdivision—using this term to include also the great trough faults—are to be found fragments of Miocene beds which in size range upward into great masses of many square miles in area. The exposures of Devonian rocks, although neither so numerous nor so well graded in size, differ in no essential structural feature from these fault-involved Miocene beds.

Again, the Reefton plateau is determined on the north-east by a great zone of dislocation, producing a relative downthrow to the south-westward; and if this view is substantially correct it follows that the high hills and mountains on the north-east side of this zone really represent rocks of a lower horizon than those to the south-west. The Devonian rocks are associated with the depressed portion of the Aorere Series, and they stop short at the outer edge of the zone of dislocation; nor is there any trace of them in the mountains to the north-east that are formed of Aorere rocks stratigraphically lower in the sequence. These facts are consistent with the writer's view that the Devonian rocks are superimposed upon the greywacke and argillite, and are directly antagonistic to McKay's opinion that they underlie them.

In a general way the following considerations are also worthy of notice: Cox and McKay offer as proof of unconformity between the Reefton and Aorere beds the fact that different members of the Devonian Series are in contact with the latter strata at different points. The present writer has endeavoured to show that these occurrences are due to faulting, and are not proof of unconformity. If the fossiliferous rocks are covered by the Aorere beds it is strange that they have not, elsewhere in the extensive areas occupied by the latter, been exposed by denudation. Further, no patches of the Devonian strata, which consist of rocks not readily disguised by thermal metamorphism, have been found resting on the plutonic masses of the subdivision, and no fragments entangled in those rocks have ever been recognized.

Age and Correlation.

The officers of the old Geological Survey consistently advocated a Devonian age for the beds here considered. Statements to this effect may be found in the reports of geological explorations by Hector* and McKay†, while Cox‡ maintains a neutral attitude. Hutton§ placed the Reefton beds in his Takaka System of Siluro-Devonian age, correlating them with a similar sequence of rocks developed in the valley of the Baton River. Park|| and Marshall¶ are in practical agreement with Hutton on both points, the former placing them in his Wangapeka Series and the latter in his Baton River System, both thus ascribing a Silurian age for the group. Dr. J. Wanner, of Bonn, paid a visit to the Reefton district in 1910, and cursorily examined the sections exposed along the Inangahua and Lankey Creek. He stated** that the rocks reminded him strongly of the Devonian sequence of the Eifel region, and that they were undoubtedly of Lower Devonian age. He positively identified *Pleurodictyum problematicum*, and tentatively named species of *Orthis*, *Chonetes*, and *Stringocephalus*. Late in 1911 the collections of fossils belonging to the Geological Survey from the Palæozoic rocks of Baton River and Reefton were submitted to Mr. W. S. Dun, of Sydney, for examination, who has not yet furnished a report, but in a private communication to Dr. J. Allan Thomson writes that the fossils of the Reefton beds have a decidedly Devonian facies, while those of the Baton River have an equally Silurian aspect. The paucity of trilobites in species, but more particularly in individuals, is another fact pointing to a Devonian in preference to a Silurian age for these rocks.

As already stated, some authorities correlate the fossiliferous Palæozoic rocks of Reefton with the similar rocks of Baton River. The close lithographical resemblance of the two sequences was first pointed out by McKay, who, however, always insisted that they differed in age. Hector†† says that "There are many fossils identical from the two localities," and gives a table, which, however, is little more than a repetition of his previous statement. Lists of all fossils identified from Baton River and Reefton have been prepared by Thomson,‡‡ and these certainly do not show many species common to both localities. In the opinion of the present writer the weight of evidence strongly supports a Lower Devonian age for the Reefton rocks, and separates them from those of the Baton River.

* Hector, J.: Progress Reports, 1873–74. Rep. Geol. Explor. during 1873–74, No. 8, 1877, p. xiv.

† McKay, Alex.: "On the Geology of the Reefton District, Inangahua County." Rep. Geol. Explor. during 1882, No. 15, 1883, p. 104.

‡ Cox, S. Herbert: "Report on Westland District." Rep. Geol. Explor. during 1874–76, No. 9, 1877, p. 74.

§ Hutton, F. W.: "The Geological History of New Zealand." Trans., vol. xxxii, 1900, p. 104.

|| Park, James: "The Geology of New Zealand," 1910, p. 40.

¶ Marshall, P.: "Geology of New Zealand," 1912, p. 178.

** In conversation.

†† Hector, J.: Progress Report, 1882. Rep. Geol. Explor. during 1882, No. 15, 1883, p. xxv.

‡‡ Pal. Bull. No. 1, 1913, pp. 30, 31.

The marble and quartzose schist developed in the upper valleys of the Grey and Maruia rivers, although now showing no recognizable fossil remains, may well be the metamorphosed equivalents either of the Reefton beds or of those occurring in the Baton River. The tuffaceous argillites and greywackes that form the lowest known rocks of the Devonian sequence at Reefton indicate that the volcanic activity so characteristic of the Devonian period in the Northern Hemisphere also obtained in New Zealand. It is possible that the volcanic action here evidenced is related to the great eruptions that caused the formation of the breccia of the Te Anau System, which Hector placed in the Devonian. In view, however, of the unsatisfactory state of our knowledge of the general Palæozoic sequence in New Zealand, such a correlation can only be regarded as extremely hazardous.

Palæontology.

Hector and Hutton have each described a species of trilobite. Hector has figured one species each of *Avicula* and *Strophomena*, while a few other identifications have been made. Thomson* gives the following list:—

Avicula sp. ind.
Chonetes striatella Dalman.
Homalonotus expansus Hector.
Homalonotus sp. ind.
Leptæna bipartita Salter.
Orthis crassa Lindstrom.
Orthis grandis.
Orthis interlineata J. de C. Sowerby.
Spirifer cultrijugatus Römer.
Spirifer speciosus Schlotheim.
Spirifer vespertilio G. B. Sowerby.
Stricklandia byrata J. de C. Sowerby.
Strophomena sp. ind.

To this list may be added—
Pleurodictyum problematicum Goldfuss.
Stringocephalus sp.
Tentaculites sp.†

No authoritative identifications of the numerous madreporian and other corals that occur in the Devonian limestone have yet been made.

MAWHERANUI SERIES.

Resting with great unconformity on the Palæozoic rocks and the granites that intrude them are rocks referable to the Mawheranui Series, the oldest beds of the Tertiary era developed in the subdivision. Their full succession is not represented in the area examined, the Kaiata mudstone, that closes the sequence, being entirely absent, although generously developed in the adjacent Greymouth and Buller-Mokihinui subdivisions. The Island sandstone and Paparoa beds, prominent members of the series in the Greymouth Subdivision, outcrop along the southern boundary of the area here considered, but as these occurrences were examined and mapped in connection with Bulletin No. 13 the reader is referred to that publication for further information concerning them. On the other hand, the Hawk's Crag breccia has in this district its

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* Pal. Bull. No. 1, 1913, pp. 31, 32.

† In the Canterbury Museum, *inter alia*, are specimens of Reefton fossils labelled *Homalonotus herschelli* and *Spirifer bisulcata*.

most southern exposures. These and other facts of a like nature may be tabulated thus :—

——	Greymouth Subdivision. Thickness.	Reefton Subdivision. Thickness.	Buller-Mokihinui Subdivision. Thickness.
Kaiata mudstone	3,000 ft. (max.)	Absent ..	1,500 ft.
Island sandstone	500 ft. "	" ..	Almost undeveloped.
Brunner beds	500 ft. or more	500 ft. or more	500 ft. or more.
Paparoa beds	1,900 ft. to 3,200 ft.	Almost absent*	Absent.
Hawk's Crag breccia ..	Absent ..	4,000 ft. or more	3,000 ft. (?)

* Paparoa beds occur on the southern boundary of the district, but were not examined by the writer (see Bull. No. 13).

The precise relationship between the Paparoa beds and the Hawk's Crag breccia is not known, and it is possible that they are deposits identical in age. It should be noted that it is the upper members of the Mawheranui Series that are absent from the Reefton Subdivision, and this naturally suggests that they have been removed by denudation. This, however, is a question that will be discussed on a later page.

Distribution and Structure.

The rocks of the Mawheranui Series cover in all an area of thirty-seven square miles within the Reefton Subdivision, and this includes the narrow strip occurring irregularly along the western part of the southern boundary of the district. The greater proportion of this area is comprised in two irregular patches of nearly equal size, covering each a flank of the southern portion of the Paparoa Range. That on the eastern side extends from Moonlight Creek to the Freeth River, a distance of seven miles and a half, and has a maximum width of about three miles. This occurrence consists essentially of three elongated blocks lying side by side, of which the central one has been let down between the other two, while the central portion of this block is, in addition, more depressed than its extremities. The patch on the western side of the mountains stretches from the head of the Punakaiki to beyond Mount Bovis, a distance of nearly eight miles. The greatest width is exposed in Bullock Creek, of which two miles and a half have been traversed without passing through these beds. The strata throughout this section are much disturbed, especially along the western edge, where they show intense faulting. The less-shattered portion exhibits steep dips toward the north-east. The small outcrop of breccia occurring near one of the great bends of the Punakaiki has almost certainly been preserved from denudation by involvement in a fault. Breccia, indistinguishable from typical Hawk's Crag breccia, occupies a small area at the mouth of the Fox River, many miles from any outcrop of similar rock. The vast accumulation of angular and subangular material, cliffs of which form so conspicuous a physiographical feature in the lower gorge of the Buller, extends southward across the Blackwater valley into the basin of Fletcher Creek. There the rock is exposed for a few chains in Hunt Creek, while débris from the hills shows that these beds have a more considerable development than is indicated by the limited extent of their outcrop along the streams.

The lower beds of the Mawheranui Series in the Greymouth and Buller-Mokihinui subdivisions are typically conglomerate, pebble-beds, grit, sandstone and shale with coal-seams. Such beds also occur in the area here dealt with, but to a limited extent only, These rocks cover a small patch in the basin of Slaty Creek, but are so closely associated with the breccia-conglomerate beds that it has been found impracticable to separate them from the latter on the map. A much larger area, probably at one time continuous with that above mentioned, occurs on the watershed between Pike Stream on the eastern side of the Paparoa Range and the Punakaiki and Porarari rivers on the western side. Another small area north of and separated from the vast accumulation of breccia in Bullock Creek lies in the basin of the Fox River. This fragment is deeply involved in the Lower Buller fault-zone, a fact to which it owes its preservation from the active denudation prevailing on the flank of a mountain-range.

Age and Correlation.

The rocks of the series here considered contain no internal evidence of their age except a few plant-remains, and, beyond the facts that they overlie with great unconformity the basal sedimentary and plutonic rocks, and underlie with undoubted though possibly moderate discordance the younger Tertiary deposits, do not, as far as the Reefton Subdivision is concerned, permit of their position in the chronological sequence being more definitely fixed. There can be no doubt, however, of the correlation of the breccia and breccia-conglomerate, that form by far the greater bulk of the deposits, with similar beds in the Buller-Mokihinui Subdivision, and to the publications dealing with that and the Greymouth Subdivision the reader is referred for a discussion concerning the age of these beds.*

Stratigraphical Succession and Conditions of Deposition.

The junction between the Mawheranui beds and the underlying rocks was observed at four points only—namely, Ten-mile Bluff, Moonlight Creek, Slaty Creek, and Fletcher Creek. In each of these localities the junction has these facts in common: that the surface of contact is flat or very gently undulating, and that the older rocks, whether granite or greywacke, are bleached and decomposed. Thus north of the Ten-mile Bluff the lower rock is much-jointed rotten greywacke, and the junction is exposed on the rock-shelf at low water as a gently curving line. At Moonlight Creek the surface of contact may be traced along the north bank for many chains near the confluence of Granite Creek, and here also the underlying greywacke is decidedly altered and bleached. At the other localities mentioned the Mawheranui beds rest on granite which exhibits unmistakable signs of decomposition. The junctions, though not nearly so well exposed as in the localities already mentioned, nevertheless indicate the existence of a fairly flat surface on which deposition took place.

Northward from Ten-mile Creek the basal beds of the series are made up of conglomerate bands with occasional layers of grit and sandstone. The boulders, some of which may have a maximum dimension of over 1 ft., are of greywacke exclusively, and most of the pebbles are of the same material, although some of the smaller are quartz. The intervening spaces are filled with sandy material.

At the other localities where the actual basal beds are to be seen these consist of breccia that contains, at Moonlight, only greywacke - fragments; in the Freeth valley, granite with occasional pieces of hornfels, a mixture to be found in the rocks outcropping at the mouth of the Fox River; while in Hunt Creek the fragments are entirely granitic, a condition also obtaining throughout the vast deposits of breccia occurring in the Porarari River and Bullock Creek. The breccia consists of angular and subangular blocks of varying size, the largest, up to at least 6 ft. in diameter,

* N.Z. G.S. Bull. No. 13, 1911, p. 52; N.Z. G.S. Bull. No. 17, 1915, p. 72.

being seen in Bullock Creek. These are set in finer material of the same general composition as the larger fragments, and cemented by iron oxide, which imparts to the breccia a characteristic reddish or purplish tint. Perhaps the best idea of the sequence is given by the exposures in the Freeth and Slaty Creek valleys, although the occurrence of faults in this locality obscures some of the sections to a certain extent. The breccia here is on the whole fairly fine, and the lower layers contain more hornfelsic material than the higher, which in turn contain a greater proportion of fine material, and often show layers of sand and conglomerate. This finally gives place to beds containing no coarse angular material, and consisting of alternate layers of coarse and fine conglomerate, grit, sandstone, shale, and mudstone. In the conglomerate layers the boulders, which are very well rounded and up to 2 ft. in diameter, are set in gritty sand, the whole being obviously beach deposit. Indeed, the sequence of the beds above the breccia undoubtedly proves the existence, during their deposition, of littoral conditions in this part of the subdivision. Occasional thin layers of carbonaceous matter also occur in connection, indifferently, with the beds of shale, grit, or conglomerate. An analogous set of beds, although very much faulted, outcrops in the basin of the Fox River, where the headwater branches of that stream break from the Paparoa Range. There, however, the grit is altered to quartzite, and the coaly bands contain anthracitic coal in place of the lignitic material contained in the beds of Slaty Creek. The Fox River beds are separated by a fault from the gneiss of the mountains, and are not in direct contact with the breccia layers developed so generously in Bullock Creek a little to the southward. In the Moonlight Creek section the lower portion of the breccia is entirely free from granite-fragments, which make their appearance only in the upper beds. The small exposure of the breccia at the mouth of the Fox River in its higher portion contains an increasing proportion of rounded stones, and the section closes with white grit and pebble-beds containing carbonaceous matter.

Von Haast, who was the first to examine an area of these unusual deposits—*i.e.*, that at the mouth of the Fox River—considered that it represented "the detritus brought down by the torrent from a granitic mountain."* McKay† is rather doubtful as to the mode of formation of the breccia, and suggests a glacial origin. Morgan and Bartrum,‡ who examined the great deposit of this breccia occurring in the Buller Gorge, conclude that it is of pluvial origin mixed with more or less true talus, the whole being derived from zones of crushed rock. The facts relied upon—namely, the coarseness of the material, its high textural range, its rapid change in composition, and the abundance of small angular fragments—are equally applicable to the breccia occurrences of the Reefton Subdivision, while the total absence of rock-flour (the fine material being always sand or grit) precludes the possibility of the deposits being of glacial origin. Permanent mountain-streams, however, no doubt contributed to the formation of the deposits, which therefore are not strictly pluvial in the sense defined by Trowbridge.§

The existence of the beds of the Mawheranui Series is proof of a land-depression, and wherever the surface of the more ancient rocks can be seen it shows the gentle undulations characteristic of a land-surface of low relief. On the other hand, the breccia and breccia-conglomerate are evidence of the existence of very steep slopes, such as could not have persisted throughout the period necessary for the base-levelling

* Haast, J. von: Rep. of a Top. & Geol. Explor. of the West. Dist. of the Nelson Prov., N.Z., 1861, p. 110.

† G.S. Rep. during 1882, No. 15, 1883, p. 143.

‡ N.Z. G.S. Bull. No. 17, 1915, pp. 76, 77.

§ Trowbridge, A. C.: "A Classification of Common Sediments and some Criteria for Identification of the various Classes." *Journal of Geology*, vol. xxii, No. 4, May–June, 1914, pp. 425–27.

of the surface on which the Mawheranui beds, whether of terrestrial* or subaqueous deposition, were laid down. Since the Mawheranui deposits are the first of a great series of Tertiary beds, and since all the deformative movements affecting the West Coast area subsequent to their deposition have been of the plateau-forming type, it is reasonable to suppose that the Tertiary era as a whole was ushered in by similar earth-movements. Plateau-forming movements are characterized by the opening of great faults and the formation of fault-scarps, features that would cause the accumulation along their bases of deposits such as are here considered.

GREYMOUTH (OR MIOCENE) SERIES.

Miocene strata are very well developed in the Reefton Subdivision, in which they cover in all 186½ square miles. In this report they have been divided into two groups and five sets of beds, arranged in descending order as follows:—

Upper (or Pareora) group—

1. Deltaic sandstones, claystones, and conglomerates (present only in the inland region).
2. Marine sandstones and claystones. (Blue Bottom.)

Lower (or Oamaru) group—

3. Limestones and calcareous grits, sandstones, and claystones. (Cobden limestone.)
4. Littoral conglomerates, grits, sandstones, and shales.
5. Breccias and breccia-conglomerates.

The unconformable relationship of the Greymouth and Mawheranui series is definitely proved by the section near the mouth of the Fox River.† Here breccia, which grades upward into grit and sandstone, is exposed for over a mile. The beds dip consistently eastward at from 30° to 40°, and form the base of hills, on the flanks of which they nowhere rise more than 100 ft. The actual junction of the two series was not observed, but the upper portions of these hills, are of the conspicuous Cobden limestone, here several hundred feet thick, and lying almost horizontal. The intervening portions are formed of soft sandstone containing several outcrops of flat-lying coal, which, if they belong to the same seam, indicate a south-easterly inclination of about 1 in 100.

In Hunt and McMurray creeks Cobden limestone, without the intervention of coal-bearing beds, apparently directly overlies the Hawk's Crag breccia. Faulting however, is probable in both these sections.

Distribution.

The rocks of the Greymouth Series occur in two main areas, separated by the Paparoa Range. The coastal section begins just north of Barrytown as a narrow exposure between the mountains and the sea, an exposure which steadily expands northward until on the boundary of the subdivision it is nine miles in width. The inland section occupies the entire floor of the great rift-valley, although the rocks are covered over large areas by more modern gravels. Portions of this inland section also occur on the Orikaka and Reefton uplands, lying in places in continuity with the main sheet and sometimes as outliers isolated by denudation.

Breccia and breccia-conglomerate are locally developed as the basal members of the Miocene sequence, but they have a limited distribution. One small elongated area stretches from the head of Boatman Creek south-eastward across the Waitahu to the flanks of Mount Albert. Another even smaller area occurs close to Reefton,

* The state of oxidation prevailing throughout the breccias, as indicated by their general red colour, is strong evidence that they accumulated under subaerial oonditions.

† See also McKay, A., Rep. Geol. Explor. during 1873–74, No. 8, 1877, p. 108; and Morgan, P. G., Trans., vol. xlvi, 1914, p. 275.

and may be traced from the traffic-bridge crossing the Inangahua at the town into the head of Soldier Creek.

Conglomerate, grit, sandstone, and shale, evidently of littoral deposition, form in general the lowest beds of the Miocene. In the Reefton Subdivision these rest either on the breccia-conglomerate or on the fundamental rocks of the locality, be they Palæozoic sediments or acidic plutonics. The littoral beds are succeeded by soft greenish-blue sandstones and claystones of off-shore origin, and frequently calcareous, which also occasionally lie directly on the old rocks. In the coastal region the littoral beds, followed by the off-shore, outcrop beneath the limestone *cuestas* from the northern boundary of the subdivision to the Gentle Annie Rocks, south of which the subaqueous phase was observed to lie directly on the granite as far as Te Miko cliff. Beyond this the gentle southerly dip of the beds brings the Cobden limestone to sea-level. Along the western base of the Paparoa Range the littoral and off-shore phases appear as a narrow strip upturned by the Lower Buller fault from north of the Porarari to the Waiwhero. In the Grey-Inangahua valley, along the eastern side, littoral beds, with a considerable thickness of the off-shore facies overlying, outcrop from Little Flaxbush Creek as far south as Ram Creek. They again appear at Capleston, and may be traced from that township to Devil Creek. Large outliers of Miocene strata, consisting chiefly of the littoral deposits, lie in structural troughs among the Reefton hills. On the western side of the Inangahua graben the rocks occur in Fletcher and McMurray creeks, but north and south of this they are concealed by the overlap of younger strata. They again outcrop across the Buller from Three-channel Flat, but their structure here is obscured by river-gravels. They appear from beneath younger rocks of the same sequence at Coal Flat in the upper valley of the right-hand branch of Welshman Creek, and at Burley's, east of Berlin's. Two small isolated areas of these rocks occur in Garden Gully and Fitzgerald creeks, small tributaries of Moonlight Creek, where they have been protected from denuding agents by involvement in a powerful fault-zone.

The Upper Miocene beds are represented in the coastal region by thick layers of sandstone and claystone, which are frequently calcareous and contain numerous shelly beds. These overlie the limestone, and from them the depression next the Paparoa Range has been carved, while southward of the Punakaiki they reach almost to Barrytown. In the inland region the beds of the upper group of the Miocene form the floor of the whole of that portion of the rift-valley drained by the Grey, and also the greater part of its northern section drained by the Inangahua. Outside of the graben the only rocks that can be referred to this portion of the Miocene sequence cover a small area in the basin of Sawyer Creek. Deltaic beds, however, form the greater part of the Tertiary strata in the graben. The marine phase is represented by a comparatively narrow strip which lies between the deltaic gravels and the granite of the Paparoa Range from Giles Creek to the Te Wharau. Farther north the beds rest on limestone, but still have no great breadth of exposure. Near Landing Creek, however, they flare out, and they also cover a considerable area toward the Brunner Range. Along the north bank of the Waitahu, down-stream from the bridge on the road to Capleston, an excellent section of these beds is exposed, although a very small area is here covered by them. Another small patch of the marine beds is cut through by Moonlight Creek, and the soft sandstone out-cropping along upper Caledonian Creek is considered to belong to the same part of the Miocene sequence. The deltaic phase of the Upper Miocene beds is not definitely represented in the coastal region, although the pebble layers noted in the Buller-Mokihinui Subdivision* indicate close proximity to land.

* N.Z. G.S. Bull. No. 17, 1915, p. 82.

Structure.

The structure of the Miocene rocks is very simple. Since their deposition it is evident that although the rocks of the Reefton Subdivision have suffered great changes in elevation this has been brought about by radial movements, and not by tangential pressure. Thus the littoral beds of the Oamaru Series are to be found resting on the basement rocks at heights ranging from sea-level to nearly 4,000 ft.; and this within a few miles. Nevertheless, the rocks as a whole have but gentle dips over wide areas, and it is only in proximity to faults that they are contorted or assume a vertical attitude.

In the coastal region the Miocene rocks rest on an earth-block, depressed relatively to the earth-blocks that make up the Paparoa Range. The Tertiary beds are in places horizontal, but have in general a gentle dip toward the mountains, while in addition there is an easy undulatory structure north and south along the length of their exposure. Thus at Candlelight, in the Charleston district, five miles north of the subdivision, the basal beds lie at 600 ft. above the sea, which to the southward they gradually approach, until at Brighton they are little above tide-mark. Farther south, at the Gentle Annie Rocks, they are nearly 400 ft. above the sea, while at Te Miko, another two miles to the south, they are again at sea-level. The great cliff at this locality owes its origin, in fact, to the ease with which the waves can cut away the weak rocks at the base of the sequence. The southward pitch of the whole series at this point is maintained to Barrytown, where the upper beds disappear beneath the beach-gravels. This undulatory structure, which is also manifest beyond the northern boundary of the subdivision, has probably been brought about by the unequal friction and downslip along the Lower Buller fault that limits the earth-block on the east. It should be noted that towards the south, in which direction the Tertiary beds plunge, the peaks of the Paparoa Range also progressively decrease in height. As the strata, gently dipping towards the eastward, approach the main fault the beds flatten, and sometimes are even upturned for a short distance. From Bullock Creek nearly to Canoe Creek a narrow inter-fracture plate of steeply dipping Miocene rocks separates the main mass of the Tertiaries from the older rocks of the range. The western edge of the coastal earth-block as well as the eastern is bounded by a great fracture, which has upturned the limestone at the mouth of Limestone Creek, and crushed the strata on the road about half a mile south of the Fox, and again at White Horse Terrace, just beyond the northern edge of the subdivision.

In the inland region the Miocene rocks cover an earth-block that has been let down relatively to the blocks on either side. The structure of the Miocene rocks that floor the valley is obscured over a great part of the graben by later gravels, but a sufficient number of outcrops were observed to show that as a whole the attitude of the beds has been but little affected by earth-movements. Along the edges of the depression the strata are usually upturned, but this is by no means a constant feature, and for long distances both in the Inangahua and Grey sections of the graben no outcrops occur at the mountain-base across what is probably the fracture-zone. In the Inangahua Survey District the Miocene rocks rise from the graben to the low hills lying to the west by what must be considered a fractured monoclinal. A similar structure prevails along the eastern edge of the depression from Capleston to south of Reefton, but in this locality denudation has removed the upper portion of the curve and also large areas of the elevated strata.

Stratigraphical Succession and Conditions of Deposition.

The basal breccia and breccia-conglomerate of the Miocene are closely comparable with the similar beds that occur at the bottom of the Eocene sequence. In different localities they show great variation. In upper Boatman Creek they contain enormous granite masses (up to 12 ft. in diameter), angular and subangular, set in a matrix of grit containing smaller fragments. The lower portion of these beds exhibits no sign of stratification, but higher up they contain layers of coarse sand showing strike and dip. On the south bank of the Waitahu, just below the Montgomerie junction, is an exposure of these beds, which here consist of angular, fairly fine, even-sized hornfelsic greywacke. The matrix, which is very scanty, is decidedly sandy, and not clayey. Near Reefton the stones are of greywacke and argillite set in a distinctly clayey matrix, and here the beds are reddened with oxide of iron, and are often much decomposed. The origin of deposits of this nature has already been discussed. Briefly, they represent talus and pluvial accumulations from fault-shattered slopes.

The deposits just described are of quite limited distribution, and the general basal strata of the Miocene are conglomerate, grit, shale, and mudstone, which at many places contain valuable coal-seams. Field-work in the Reefton Subdivision has shown that these beds were deposited on a gently undulating surface, which was probably a base-levelled land-surface prior to the Miocene depression. Over such a surface a slight subsidence would permit a wide transgression of the sea, and, if the off-shore currents were not too strong, conditions favourable to the accumulation of beach deposits would be created. That the strata considered under this head are beach deposits is shown by their nature. They range from conglomerate, of which the larger pebbles are of resistant rocks exceedingly well rounded, to fine sand. As the fragments decrease in size they become less smoothly rounded, and a sharp grit is probably the most characteristic rock. The grit-beds are of various degrees of fineness, but the separate layers have always been well assorted, according to size, by the waves. Current bedding is very common, while shell-fragments* and the occasional subangular stones of the intertidal sand beach are characteristically developed. Sometimes lagoonal conditions prevailed, for beds of fine carbonaceous mudstones, such as to-day form the mud-flats of sheltered inlets along the New Zealand coast, occur in places. These exhibit remains of sand-burrowing and other molluscs. Often the lime has been concentrated into calcareous concretions, whilst in one locality mud-cracks were noted. The argillaceous beds are usually decidedly micaceous, and when rapid alternations with fine sands occur a shaly rock results. The auriferous blacksand-leads of the modern beaches have their prototypes in the "cements" of Oriental, Lankey, Murray, and Boatman creeks, in which, however, the ironsand is now represented by marcasite. At Capleston the old lead is on a false bottom, in that it rests on the sands of that period, and not on the basement rocks, as at the other localities. Terrestrial or paludal conditions occasionally obtained, as is indicated by the occurrence of coal-seams, the origin of which will be discussed on a later page.

As the depression of the land proceeded the sea transgressed more and more on the gently shelving surface, and beach deposits formed again and again along the new strand-lines. Thus a series of littoral beds exist, ranging in age throughout the whole period during which depression lasted. Occasionally the beach deposits are entirely wanting, as at Te Miko cliff and Inangahua Junction, and it may be supposed that at these points the scour of the waves was sufficient to sweep the underlying rock clear of all loose material. Again, in certain localities conditions were peculiarly

* These occur below the coal-seams at the Waitahu River and Fletcher Creek.

favourable for the accumulation of littoral beds. Thus at Capleston and in the Waitahu valley Miocene beach deposits have a very great development, attaining a thickness of at least 1,000 ft.

As the strand-line moved inland the earlier littoral beds were covered by the sea to an increasing depth, and material deposited under these conditions exhibits appropriate characteristics. The beds overlying the beach deposits usually consist of greenish-grey sandstone, rapidly alternating with thin layers of bluish claystone. Higher in the sequence the different layers become thicker, the sandstone-beds more massive, and the claystone more and more calcareous, finally grading into the Cobden limestone that immediately overlies. In the coastal region these off-shore deposits attain a thickness of perhaps 400 ft., but the uncertainty of the horizon that forms the top of this set of beds makes any estimate of thickness worthless. It may be stated that this part of the Miocene sequence is much more poorly represented in the inland region, a fact giving additional support to the thesis of overlap developed in succeeding paragraphs.

The material that forms the littoral beds must have been derived from pre-existing deposits of similar nature or from acidic plutonic rocks. Both these possible sources of supply are available within and contiguous to the Reefton Subdivision. The greenish-blue sandstones and claystones of the off-shore deposits have their prototypes in the Palæozoic greywackes and argillites and the similar rocks of Mesozoic age that form the Alpine chain.

The beds constituting what is usually termed the Cobden limestone represent a period of further depression of the area forming the Reefton Subdivision. The deepening of the water, the increasing distance from the land due to the transgression of the sea, together with the lessening area from which detritus could be derived, brought about conditions favourable for the deposition of calcareous beds. The change in character from the off-shore deposits is usually, but not always, quite gradual. Along the present shore-line the limestone varies from 300 ft. to 600 ft. in thickness, but inland in the coastal region is somewhat less, since the tendency is for the beds to grade into calcareo-arenaceous deposits toward the Paparoa Range, which had been previously uplifted and was not totally submerged during this period (see later). At the mouth of the Punakaiki the limestone grades upward into a white gritty sandstone, which, over an area of at least a square mile, contains water-worn fragments of coal. The significance of this will be discussed on a later page.

In the Grey - Inangahua graben shallow - water conditions in places lessened or prevented the accumulation of limestone. Thus along the eastern flank of the Paparoa Range the calcareous deposits of Inangahua Junction, which are about 400 ft. in thickness, extend southward with diminishing thickness until, where the Te Wharau breaks from the mountains, they taper out in the form of a calcareous grit against the basal granite. Eastward from Inangahua Junction the limestone merges into lime-bearing claystone, which is well seen on the saddle where the road crosses from the Dee to Three-channel Flat. Still farther eastward only a single layer, 3 ft. to 4 ft. in thickness, of obviously calcareous sandstone is intercalated in a great thickness of rapidly alternating thin-bedded claystone and sandstone. This indicates a sea-bottom well within the influence of wave-action. Farther north, in the basins of New and Pensini creeks, the conditions were evidently more favourable for the formation of limestone, for in these localities the calcareous beds are much more generously developed. Southward along the flank of the Brunner Range no outcrops were noted for many miles. It is highly probable that the great depression forming the Inangahua-Grey graben was open to the sea northward across the basin of the Orikaka and Ngakawau, while it is certain that connection was made with the open ocean southward. It may be asserted with considerable confidence that the Paparoa Range, at the time of the deposition of the limestone, formed an island. In the calcareous strata exposed in Tobin Creek, near the foot of the Victoria Range, are bands containing numerous angular fragments of granite and hornfels, the whole forming a breccia with a calcareous matrix. This indicates deposition close to a steep coast formed of hard rock, and since the occurrence is close to a post-Miocene major fault it is probable that the Miocene shore was determined by the same fault.

In the coastal region the Cobden limestone is succeeded with perfect concordance by massive blue fine-grained sandstones or mudstones, known on the West Coast as the "Blue Bottom." Usually the upper members of the limestone grade into these beds, and it is impossible to separate them precisely, but near the mouth of the Punakaiki the top of the limestone merges into a white gritty sandstone, quite distinct from the soft blue sandstone overlying. Evidently in this locality some decided change took place in the conditions of deposition. The Blue Bottom beds manifestly were deposited in shallow water. They contain shelly bands, and in places the fossils are so numerous as to make thick layers of rock, rich enough in lime to deserve the name of arenaceous limestone rather than calcareous sandstone. The sections of these beds examined in the coastal region were not of a nature to yield data as to their original thickness; nor is this surprising when it is considered that elevation took place at the close of this period, and has been maintained, with the exception of one partial submergence, to the present day.

In the inland region the strata of this period show considerable variation. In the Inangahua Survey District the thickness of the Blue Bottom beds recalls that of the coastal region, although here the beds are much less calcareous. In their upper portion they contain layers of even-sized conglomerate and occasional bands of lignitic material. Along the flanks of the Paparoa Range the Blue Bottom beds grade upward from the limestone, and show overlap on the underlying granite from the Te Wharau to south of Giles Creek. In this locality the marine beds are much less fully developed, there being a thickness of only a few hundred feet of strata beneath the lignitic bands. These evidences of terrestrial conditions are only a few inches in thickness, but may be continuous for many chains. They are overlain by blue unfossiliferous sandstones similar to the beds underlying, which, however, contain a rich marine fauna. Other layers of lignite overlie, often in rapid succession, and beds of blue conglomerate fairly well consolidated, and consisting of even-sized water-worn flakes of quartzose schist in a blue sandy matrix, become more and more frequent; in fact, the sandstone layers become subordinate and finally disappear. Still higher in the sequence a few granite and greywacke pebbles appear among the schistose fragments, and these, particularly the granite, are larger than the other pebbles, and the beds on the whole tend to lose their even texture. At the same time they become more oxidized, even in the fresh sections. Beds of the types described cover the whole floor of the graben southward from near The Landing. Over large areas they are concealed by more recent gravels; but the distribution of their outcrops within the depression, as well as the general structure of the rift-valley, leave no room for doubt of the truth of the above statement. The coarser beds of the series are most largely developed in the Inangahua valley from Reefton as far north as Fletcher and Brown creeks, although the sandstones containing lignitic bands and occasional layers of conglomerate appear at many points through the younger gravels of the Grey as well as beneath those of the Inangahua valley. Within the Grey-Inangahua trough the whole group of beds above the limestone constitutes an ancient delta, of which the marine deposits represent the widespread bottom-set beds, and the oxidized upper deposits the typical top-set beds. The blue sandstones and claystones, with bands of lignitic material and with seams of brown coal, are evidently top-set beds formed during a period of intermittent depression; while the thick strata of blue conglomerate, with but a few sandstone layers and devoid of lignitic bands, are fore-set beds lying over older top-set deposits. The deltaic accumulations may be traced northward as far as Brown Creek, and southward beyond the southern boundary of the subdivision; in fact, beds of this type are reported as far south as Ross.

There is no difficulty in providing a near-by source for the gravels of North Westland, but those of the Inangahua valley must have come from the metamorphosed zone of the Alpine overthrusts. The nearest point at which schists occur *in situ* is along the Spenser Range, and the stream or streams that carried the pebbles to where they now form conglomerates must have borne them across a belt of granite and greywacke fully twenty miles in width. The total absence of spoil from these rocks in the lower portion of the conglomerate, and its sparing occurrence in the upper layers, suggest that during this period the belt intervening between the source of the spoil and the area of deposition was at first of very low relief, but that later, probably from a rejuvenation of the river-system through elevation, it contributed a small amount of waste to the stream-channels. The Alpine Range at this time must have had considerable relief, otherwise it is impossible reasonably to account for the great thickness of conglomerate forming the deltaic deposits.

Relationship of the Cobden Limestone and Overlying Beds.

It has been stated above that the Blue Bottom beds generally follow the Cobden limestone with perfect conformity. This is in agreement with the observations of McKay, Webb, Morgan, and Bartrum throughout the West Coast in general. While this is the case over the greater part of the Reefton Subdivision, there are two localities in which marked discordance exists between the Blue Bottom and earlier Miocene beds. On the right bank of the Waitahu, just below the bridge on the short track from Reefton to Capleston, is a high cliff, in great part bare of vegetation. Its base is formed of a hard grit containing sporadic stones, and evidently an ancient beach deposit. This bed has a strike of N. 20° E., and a dip of 30° to the westward, and is underlain by sandstone containing pyritic concretions, the strata beneath which are not exposed, but probably consist of the dark concretionary mudstone with Miocene fossils that outcrops a few chains up the track leading to Capleston. About 20 chains above the bridge sandy shales, with a strike and dip corresponding with that of the beds at the bridge, occur, and these shales form the first outcrop of a section of coal-bearing littoral beds that outcrop continuously for about 40 chains along the river-bank. The strike here is also N. 20° E., and the dip westerly, while a similar structure prevails in the littoral beds of Flower and Boatman creeks. It seems a reasonable inference that the beds at the base of the cliff near the Waitahu Bridge are part of a large block of Lower Miocene strata. The hard grit above referred to grades upward into incoherent sands, in the upper part of which small pieces of detrital coal occur. The rotten conglomerate that overlies also contains coal-fragments, and is, moreover, formed largely of rounded fragments from the underlying Miocene beds. At this point the section is obscured by for st growth. A chain or so to the north-west is a well-consolidated conglomerate consisting of cobbles almost exclusively derived from the Palæozoic greywackes, and set in a gritty matrix which contains coal and shell fragments. This conglomerate is perhaps 20 ft. in thickness, and is overlain in turn by layers of soft bluish claystone and sandstone containing imperfect casts of marine shells. These beds strike N. 70° E., and dip very flatly to the west of north. That they belong to the Blue Bottom formation, and not to the similar marine beds below the Cobden limestone, is indicated by the occurrence in them, just above the conglomerate, of two thin layers of lignite. The evidences for unconformity in this locality are discordance in strike and dip between the upper and lower beds, the facts that the upper series contains water-worn fragments of the lower, and that the Cobden limestone is entirely wanting in this section. Notwithstanding this clear proof of unconformity, and that the exposure is excellent, the actual plane of junction could not be detected, although Mr. F. K. Broadgate and the writer made diligent search for it. It is probable that the lowest beds of the Blue Bottom are here composed of gritty sand derived from the littoral beds of the Miocene, and deposited on a decomposed surface of similar beds.

In McCarthy Creek, a branch of Moonlight Creek, a section is exposed showing the overlap of the Blue Bottom beds on the Palæozoic rocks. In addition to bands of lignite, there is a layer of claystone pulped by a neighbouring fault and containing fragments of coal. This rests directly on the greywacke. At a higher level and in Garden Gully, the next creek to the north, occurs a thick seam of brown coal, while in Fitzgerald Creek, also quite close at hand, occur brown coal and a fault-involved fragment of foraminiferal limestone which is correlated with the Cobden limestone. Probably, then, the Lower Miocene beds had been elevated and denuded before the deposition of the Blue Bottom.

To recapitulate: The perfect conformity of the Cobden limestone and the Blue Bottom is shown by numerous sections, which do not require enumeration, both in the coastal and inland regions of the subdivision. This strict concordance has been noted by other writers, and requires no further elaboration. On the other hand, the writer has described two sections, in one of which discordance is demonstrated and in the other at least strongly indicated. Moreover, in the coastal region the passage from the Cobden limestone to the Blue Bottom is, in one locality (near the mouth of the Punakaiki), abrupt and marked by the occurrence of water-worn pieces of coal, facts which suggest a marked change in the conditions of deposition. It is believed that at the close of the period represented by the Cobden limestone crustal stresses were adjusted in part by the depression of certain earth-blocks, and in part by the elevation of others relative to a fixed sea-level. This hypothesis adequately accounts for the unconformable sections described above, and explains both the absence of the younger Miocene rocks from the Reefton plateau and the overlap of the same beds along the western base of the Paparoa Range. The deep involvement of the older Miocene rocks along the fault-zones traversing the plateau just mentioned would suffice to preserve some of those beds even if the area were base-levelled to the present deep-cut drainage-channels; and it would be extraordinary, had the younger members of the sequence ever been deposited here, if some fragment of them had not escaped denudation. In regard to the overlap above referred to, the sections in Fletcher Creek and its branches show that the calcareous beds are here underlain by hundreds of feet of strata which are unrepresented at McMahon Creek and the Te Wharau, where the calcareous beds rest directly on the granite. That the same limestone occurs in all the streams is shown by the fact that it forms a prominent escarpment, broken only by narrow stream-valleys. The calcareous beds are not seen south of the Te Wharau, Giles Creek exhibiting a section of the higher members of the series that terminates in a shelly sandstone characteristic of the Blue Bottom. This bed, however, does not rest upon the basal granite, but is separated from it by a fault-plane.

The succession of the strata in the lower valley of the Punakaiki deserves a few remarks. The change from the more or less arenaceous limestone that constitutes the upper layers of the Cobden limestone into the blue sandy clays of the Blue Bottom is, as already stated, usually gradual, and the plane of demarcation cannot be fixed. In the locality mentioned, however, the top of the limestone merges into white gritty sandstone, occasionally somewhat calcareous, and everywhere containing water-worn fragments of coal. These are usually distributed quite sparingly, but occur abundantly in some lenticular layers. This grit is abruptly succeeded, with perfect concordance, by the usual Blue Bottom sediments. Although deposition did not cease in this locality, it is evident that a great change took place in the nature of the spoil supplied and in the conditions of sedimentation. Thus the detrital grains, from being in the limestone chiefly derived from marine organisms, in the case of the grits must have originated from a near-by land-surface. The conditions of sedimentation in a like manner show a change from the zone of minor agitation to that of major agitation, approaching in fact those obtaining in the littoral zone. It is unlikely that such abrupt changes could have been caused by the shoaling of the sea-bed by deposition, and the alternative explanation postulates an elevation of the sea-bottom and the adjacent land. The nearest land possibly existing during the deposition of the Cobden limestone is between four and five miles distant, and the intervening space is occupied by the underlying limestone layers without any cover of Blue Bottom sandstone. There is no proof of unconformity in this locality, but the facts stated strongly suggest that during the deposition of the grit containing coal-fragments the strand-line was close at hand, indicating an emergence of the sea-floor over a belt several miles in width. There are two possible origins for the coal-fragments —namely, from the coal-seams at the base of either the Mawheranui Series or the Oamaru Series. The percentage composition of the detrital coal is as under:—

Fixed carbon	45·41
Volatile hydrocarbons	35·14
Water	9·24
Ash	10·21
	100·00
Sulphur	0·71

This agrees well with the composition of many of the coals of the older series as these are developed in the neighbouring Greymouth Subdivision. Coal-measures almost certainly of this age occur at the headwaters of the Punakaiki and Porarari rivers, and coal-seams are known to be there developed. The writer, however, had no opportunity of visiting this locality, and his knowledge of the nature of the coal is confined to the examination of small fragments found in the creeks draining from the area mentioned. These fragments indicate that the coal is either sub-bituminous or bituminous in composition, and the seams may well have supplied the rolled pebbles contained in the grit. The other possible source for these is in the brown-coal seams frequently developed in the beds beneath the Cobden limestone. The nearest outcrop of the seams in these measures exists in Waiwhero Creek, four miles from the mouth of the Punakaiki. The writer neglected to take a sample of the thick seam here exposed, but it is undoubtedly a brown coal approximating in composition that exposed near Brighton, which is much higher in volatile hydrocarbons and water but lower in fixed carbon. (See analyses on p. 217). This apparently indicates that the coal-pebbles were not derived from seams of Miocene age immediately beneath the limestone.

The Blue Bottom beds near the mouth of the Punakaiki also contain innumerable particles of coaly matter, and small pebbles of coal were observed by J. A. Bartrum* in blue sandstone of the same age in the valley of the Waitakere River.

For a description of other occurrences of coal-fragments in the Oamaru rocks of the West Coast, and a more adequate discussion of their significance, the reader is referred to Bulletin No. 13, pp. 65, 66, and Bulletin No. 17, pp. 85–88, as well as to a paper entitled "Unconformities in the Stratified Rocks of the West Coast of the South Island."†

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* MS. notes. See also N.Z. G.S. Bull. No. 17, 1915, p. 89.
† Morgan, P. G.: Trans., vol. xlvi, 1914, pp. 272–74.

Age and Correlation.

The series of rocks here considered cover a wide area on the West Coast, although the lowest beds, consisting of breccia and breccia-conglomerate, do not appear to extend beyond the Reefton Subdivision.* It is considered that all the sedimentary beds below the limestone are of approximately the same age, whether they consist of the coarse deposits of the zone of major agitation or of the finer materials laid down in quieter waters. It is obvious that these sediments must grade into and replace one another both vertically and laterally. Thus the beach deposits developed to so great a thickness from Capleston to Garvey Creek are represented by blue off-shore sandstone and claystone in other localities (between Flaxbush Creek and Dee Stream and again in the coastal region). It is possible, indeed, that the upper layers of these beach deposits were laid down in a period during which in other places limestone was forming.

If the correlation of the Cobden and the Oamaru limestones is correct, it equally follows that the Blue Bottom beds that are typically developed in the coastal region in direct continuity with those of the Buller-Mokihinui Subdivision must correspond with the Pareora Formation of Hutton. In the Grey-Inangahua graben the normal marine sediments are poorly represented, all but the lowest members of the group of beds being replaced by deltaic deposits containing numerous layers of impure lignitic material. The deltaic deposits consist chiefly of even-grained conglomerate interbedded, especially towards the base, with blue sandstone layers, indistinguishable, in the absence of fossils, from similar rocks in the Blue Bottom. Webb† notes a somewhat similar sequence in his Upper Kongahu Series, with which these rocks correspond in age. In the middle Maruia district a great thickness of conglomerate, that cannot be distinguished lithologically from that of the Grey-Inangahua graben, covers a wide area. These rocks also represent an ancient delta, and present so many features common also to the deposits of the Reefton Subdivision that the difficulty is to discover points of difference. Both sets of beds consist of a similar sequence of deposits, contain numerous lignite layers, occasional leaf-beds, and thick seams of brown coal, and both yield traces of petroleum. Cox,‡ who spent a month of 1883 in a reconnaissance survey over more than 1,200 square miles of exceedingly rough and nearly roadless country, maps the conglomerates of the Maruia and Warwick valleys as lying beneath the limestone developed near Murchison, and corresponding with the Cobden limestone. He appears to have relied on the supposed major structure of the district to fix the position of the conglomerate in respect to this limestone, and as his interpretation of the facts of structure is obviously erroneous this question must be regarded as open.

Palæontology.

In regard to the list of *Mollusca* here given, the identifications are by Mr. Henry Suter. The material from the Pareora Series was collected by the writer during field-work in the years 1912–14, and the bulk of the remainder by McKay in 1874 (Collections Nos. 28, 31, 33, 38, 45, 46, 48, 49, 50, and 274). The vertical arrangement of the names in the list is according to the distribution of the fossils. The Pareora beds yielded twenty-two species, of which seven are Recent; the upper part of the Oamaru, or that portion containing the Cobden limestone and the associated strata, yielded fifteen species, of which five are living, while thirty-eight species belong to the lower part of the Oamaru, of which nine are Recent. The combined beds contain sixty-two species, of which nineteen are Recent—that is, they contain 31 per cent. of living forms.

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* They may occur in the lower Buller Gorge, west of the subdivision boundary. See N.Z. G.S. Bull. No. 17, 1915, p. 85. † N.Z. G.S. Bull. No. 11, 1910, p. 20. ‡ "On the District between the Maruia and Buller Rivers." Rep. Geol. Explor. during 1883–84, No. 16, 1884, pp. 1–10.

TABLE OF MOLLUSCAN FOSSILS.

——	Pareora Series.			Upper Part of Oamaru Series.			Lower Part of Oamaru Series.					
	Fox River.	Hunt Creek.	Moonlight Creek.	$2\frac{1}{4}$ Miles South of Brighton.	Inangahua Junction.	Landing Ferry.	Welshman Terrace.	Woodpecker Bay.	Lyell Bridge.	Rainy Creek.	St. Kilda.	Three-channel Flat.
**Ancilla australis* (Sow.)	..	..	x	..	..	..	..	..	..	..	..	..
**Ancilla mucronata* (Sow.)	..	..	x	..	..	..	..	..	..	..	..	..
**Architectonica (Philippia) lutea* (Lam.) ..	..	..	x	..	..	..	..	..	..	..	..	..
Euthria n. sp. (*cf. E. media* Hutt.) ? ..	..	..	x	..	..	..	..	..	..	..	..	..
Glycymeris cordata Hutt.	x	..	..	..	..	..	..	..	..	..	..	..
**Glycymeris laticostata* (Q. & G.)	..	..	x	..	..	..	..	..	..	..	..	..
Lapparia corrugata Hutt. ?	..	..	x	..	..	..	..	..	..	..	..	..
Lima paucisulcata Hutt.	x	..	..	..	..	..	..	..	..	..	..	..
Macrocallista pareoraensis Sut. ?	x	..	..	..	..	..	..	..	..	..	..	..
**Modiolus australis* (Gray)	x	..	..	..	..	..	..	..	..	..	..	..
**Natica zelandica* Q. & G. ?	..	..	x	..	..	..	..	..	..	..	..	..
Olivella neozelanica Hutt.	x	..	..	..	..	..	..	..	..	..	..	..
Ostrea incurva Hutt.	..	x	..	..	..	..	..	..	..	..	..	..
Pleurotomaria tertiaria McCoy	x	..	..	..	..	..	..	..	..	..	..	..
Polinices gibbosus (Hutt.)	x	..	..	..	..	..	..	..	..	..	..	..
Polinices huttoni v. Ihering	..	..	x	..	..	..	..	..	..	..	..	..
Sinum (Eunaticina) cinctum (Hutt.) ..	x	..	..	..	..	..	..	..	..	..	..	..
Siphonalia conoidea (Zitt.)..	..	..	x	..	..	..	..	..	..	..	..	..
Dentalium solidum Hutt.	x	..	..	..	x	..	..	..	..	..	..	..
**Anomia huttoni* Sut.	..	..	..	..	..	x	..	..	..	..	..	..
**Anomia undata* Hutt.	..	..	..	..	x	..	..	..	..	..	..	..
Chama huttoni Hector	..	..	..	..	x	..	..	..	..	..	..	..
Pecten (Camptonectes) huttoni (Park) ..	..	..	..	..	..	x	..	..	..	..	..	..
Pecten (Chlamys) williamsoni Zitt. ? ..	..	..	..	..	x	..	..	..	..	..	..	..
**Protocardia (Nemocardium) pulchella* (Gray)..	..	..	..	..	x	..	..	..	..	..	..	..
**Xenophora corrugata* (Reeve)	..	..	..	..	x	..	..	..	..	..	..	..
Hemithyris squamosa (Hutt.) ?	..	..	..	..	x	..	..	..	..	..	..	..
Crepidula gregaria Sow.	..	x	..	..	..	..	..	..	x	..	..	..
**Dosinia greyi* Zitt.	x	..	..	..	..	..	..	?	..	?	x	..
Paphia curta (Hutt.)	x	..	..	..	..	..	x	..	..	..	..	..
Cytherea (Circomphalus) sulcata (Hutt.) ..	..	..	..	..	..	?	..	..	x	..	..	..
**Lima (Mantellum) suteri* Dall.	..	..	..	..	x	..	..	..	..	..	x	..
Ostrea wuellerstorfi Zitt.	..	..	..	..	x	..	..	x	..	..	..	..
Pecten (Pseudamusium) hochstetteri Zitt. ..	..	..	..	x	..	..	..	x	..	..	x	..
Pholadomya neozelanica Hutt.	..	..	..	..	..	x	..	..	x	..	..	..
Pinna distans Hutt.	..	..	..	..	x	..	..	x	..	..	..	..
**Arca novæ-zealandiæ* Smith	..	..	..	..	..	..	x	..	..	..	..	..
Cardium patulum Hutt.	..	..	..	..	..	..	..	..	x	..	..	..
Cardium sp.	..	..	..	..	..	..	x	..	..	x	x	..
Cardium waitakiense Sut. ?	..	..	..	..	..	..	..	..	..	..	x	..
Chione chiloensis truncata Sut. ?	..	..	..	..	..	..	x	..	..	..	..	..
Chione meridionalis (Sow.)	..	..	..	..	..	..	?	..	x	..	..	..
Chione sp. (*cf. C. elegans* (Hutt.))	..	..	..	..	..	..	..	x	..	..	..	..
Cucullæa alta Sow.	..	..	..	..	..	..	..	..	..	..	x	x
Cucullæa n. sp. ?..	..	..	..	..	..	..	x	..	..	..	..	..
Daphnella n. sp. ? near *D. (Raphitoma) neozelanica* Sut.)	..	..	..	..	..	..	x	..	..	..	..	..
Dosinia sp. ?	..	..	..	..	..	..	x	..	..	..	..	..
Leda semiteres Hutt.	..	..	..	..	..	..	x	..	..	..	..	..
**Lima angulata* Sow.	..	..	..	..	..	..	..	..	..	..	x	..
Lima colorata Hutt.	..	..	..	..	..	..	..	x	..	..	..	..
**Ostrea corrugata* Hutt. ?	..	..	..	..	..	..	..	..	..	..	x	..
Panopea orbita Hutt.	..	..	..	..	..	..	?	..	..	x	..	..
Panopea worthingtoni Hutt.	..	..	..	..	..	..	..	..	x	..	..	..
**Panopea zelandica* Q. & G.	..	..	..	..	..	..	..	..	..	..	x	..
Pecten hutchinsoni Hutt.	..	..	..	..	..	..	..	x	..	..	..	..
Pecten marshalli Sut. ?	..	..	..	..	..	..	..	x	..	..	..	..
Pecten scandula Hutt.	..	..	..	..	..	..	x	..	..	..	x	..
Pecten sectus Hutt.	..	..	..	..	..	..	..	x	..	..	..	..
Pecten yahliensis T.-Wood	..	..	..	..	..	..	..	..	..	..	x	..
Pinna lata Hutt.	..	..	..	..	..	..	..	x	..	..	x	..
Polinices sp.	..	..	..	..	..	..	x	..	..	..	..	..
**Psammobia lineolata* Gray	..	..	..	..	..	..	..	..	..	x	..	..
Surcula n. sp. ?	..	..	..	..	..	..	x	..	..	..	..	..
Teredo heaphyi Zitt.	..	..	..	..	..	..	..	x	..	..	x	..
Trochus sp. ?	..	..	..	..	..	..	..	x	..	..	..	..
Turris sp.	..	..	..	..	..	..	..	x	..	..	..	..
Turritella semiconcava Sut. ?	..	..	..	..	..	..	..	..	..	..	x	..
Turritella patagonica Sow.	..	..	..	..	..	..	..	..	..	..	x	..
**Turritella symmetrica* Hutt.	..	..	..	..	..	..	..	x	..	..	x	..
**Venericardia purpurata* (Desh.)	..	..	..	..	..	..	..	..	x	..	..	..

* Recent species.

The various members of the Greymouth Series are of course not equally fossiliferous. Plant-remains are abundant in the littoral beds, but are rarely well preserved. The only land-plant recorded from these beds as they occur in the Reefton Subdivision is *Casuarinites*,* a form also found at Pakawau and the Grey River. Calcareous algæ of several species occur in grit a few feet above the coal in Fletcher and Flaxbush creeks. In several localities—Rainy Creek, Waitahu River, and Fletcher Creek—the littoral mudstone and sandstone layers carry marine shells. Except in the case of Fletcher Creek, where a few shell-fragments are found in a sandstone lying beneath the coal-seam of the outcrop near the granite, these occurrences are confined to beds at a higher horizon than the coal. The marine beds below the limestone are nearly unfossiliferous in their lower portion, where they were laid down under off-shore conditions. As they approach the overlying limestone, however, the conditions for the preservation of fossils improve, and these become much more common. In addition to the *Mollusca* tabulated on page 93, Hector† has described the fragmentary remains of a gigantic penguin, and Woodward‡ a fossil crab, both from Seal Island, Brighton. The species of penguin, *Palæeudyptes antarcticus*, was first described by Huxley from the Kakanui limestone of Oamaru; while the crab, *Harpactocarcinus tumidus*, was named by Woodward, and compared by him with species of the same genus occurring in the nummulitic limestone of the Upper Eocene of southern Europe. Sharks' teeth were observed in the upper portion of the Cobden limestone near Cave Point; and echinoid remains, usually in a poor state of preservation, were noted in many localities. The limestone itself is to a great extent made up of *Polyzoa* and shell fragments and *Foraminifera*, the latter being sparingly scattered throughout all the marine beds of the sequence. In the marine beds of the Pareora group fossils are everywhere at least sparingly developed, while in some localities they greatly increase in number, and form shelly bands. In the deltaic phase of this series excellent leaf-impressions are to be found in beds close to the coal-seams of Camp and Rough creeks.

PLEISTOCENE AND RECENT DEPOSITS.

The classification of the post-Pliocene deposits of the subdivision presents many difficulties, and that here adopted cannot be regarded as entirely adequate. One prime difficulty lies in the separation of the top-set beds of the deltaic member of the Pareora Series from the Pleistocene gravels. As already stated, these deltaic beds grade upward from unoxidized conglomerates containing only schist-fragments into yellow and brown gravels containing, in addition, pebbles of granite and greywacke. Now, the next succeeding set of gravels consist in part of a rewash of the Pareora conglomerates, and although generally the separation from the older series is easy, there are areas of ancient gravels concerning the age of which there is uncertainty.

The classification of the more recent gravels is by erosion cycles, and is therefore not strictly according to age. This method of division is much more satisfactory than any other for deposits of this description, although occasionally it fails. This is notably the case in the coastal region, where near Barrytown the maritime plain, which has been built during three erosion periods, rises gently and without marked breaks from sea-level to over 200 ft. above tide-mark. The reasons for this lie in the facts that the elevation during each period of uplift was effected gradually, and that the coastal plain of this locality is in a shallow bight protected by hard promontories from the erosive action of the sea that otherwise, during the intervening periods of stillstand, would have cut back the coast at this as at other points along the shore.

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* Von Ettingshausen, Constantin: "Contributions to the Knowledge of the Fossil Flora of New Zealand." Trans., vol. xxiii, 1891, p. 241. *Cinnamomum* sp. and *Fagus* sp. occur in the fireclay at Burke's Creek Coal-mine (P. G. Morgan, M.S.).

† "On the Remains of a Gigantic Penguin (*Palæeudyptes antarcticus*) Huxley, from the Tertiary Rocks on the West Coast of Nelson." Trans., vol. iv, 1872, p. 341.

‡ "On a New Fossil Crab from the Tertiary of New Zealand." Q.J.G.S., vol. 32, 1876, p. 51.

Pleistocene Deposits.

Distribution.

On the road from Blackwater to Waiuta, about two miles from the former township, the Palæozoic greywacke and argillite through which Blackwater Creek has cut its gorge give place to well-consolidated brown and yellow gravels, which are evidently of considerable thickness. The extensive prospecting operations that in this neighbourhood have been prosecuted for several years with great energy have established that a large area of Aorere rocks are veneered with these old gravels, which also fill ancient drainage-channels to a depth of several hundred feet. Similar gravels occur at the head of Brown Creek (a branch of the Big Grey), and again in the basin of the Alexander. Northward toward the Inangahua the same gravels apparently cap all the ridges and plateau-like hills at the sources and in the basins of the Snowy and Big rivers and of Antonio and Slab Hut creeks. South of the Big Grey, and overlying Tertiary beds with decided discordance, they form the hill-crests in the basin of the Waipuna, whence they stretch from Napoleon Hill to Noble's. North of the Big Grey, beyond the terraces of that river, they form the hills to the west of the Aorere rocks from the Blackwater River to Slab Hut Creek. The gravels from which the hills between the head of the Mawheraiti and Inangahua have been carved contain many schist-fragments, and are possibly of Pareora age. Near Reefton Pleistocene gravels lie on the Palæozoic and Tertiary rocks at the heads of Soldier, Liverpool Dave, and Portugee creeks, and this occurrence links them to the gravels forming the high level pakihis that lie between the Inangahua, Waitahu, Boatman, Burk, Larry, and Landing streams. In other localities the gravels here classed as Pleistocene have been well carved by stream erosion, but these pakihis, although as high as the tops of the gravel-formed hills separating the Inangahua from the Mawheraiti, are level and unsculptured. The terrace at Reefton, however, grades into hills of Pleistocene gravel ; and all are made up of gravel which is as well consolidated as, and which cannot be distinguished from, the typical Pleistocene gravels, and it is considered that these terraces are little if at all younger than the Pleistocene. Northward from Landing Creek, along the foot of the Brunner Range, the writer did not have an opportunity of examining sections of the interfluvial terraces, but doubtless the highest belongs to the Pleistocene. The high terrace north of the Buller known as Welshman pakihi is considered to belong here, and with it must be correlated Manuka Flat, a similar terrace between the Lyell and Eight-mile creeks. Patches of coarse gravel of unknown extent occur high on the flanks of the Brunner Range ; they may be seen on the track to Boundary Peak, and again near the source of Landing Creek.

Along the western side of the Inangahua-Grey valley opportunities for the study of these gravels are not numerous. Small areas, as noted by McKay, still remain on the limestone plateau near Inangahua Junction, near Rocklands Flat, and The Landing. Pleistocene gravels are also represented on the high interfluvial terraces along the eastern edge of the Paparoa Range, especially in the Inangahua valley. In the Mawheraiti-Grey valley the wide sweep of the younger terraces confines the Pleistocene gravels to the very foot of the range. They may be studied where the Otututu and the Big rivers break from the mountains, and again in the valleys of the Moonlight and Roaring Meg, where they form Shetland, Stewart, and Healy terraces.

In the coastal region fluvial gravels occur on the ridges of Miocene strata between the streams, where these cross the depression that lies just to the west of the mountains. The chief development of gravels of this age is north of Bullock Creek, and more especially north of the Fox River, where they are of marine origin. South of Bullock Creek the ridges bearing these gravels are narrower, and they were not observed to reach the basin of the Punakaiki. Along the seaward margin of the subdivision marine gravels which are considered of Pleistocene age occur as isolated patches, generally elongated in shape, at heights varying from 450 ft. to 600 ft. above sea-level. The size of these patches is inconsiderable, their shape irregular, and the thickness of the beds small. They may be studied at the source of Deverey Creek, on the ridge between that stream and Canoe Creek, and again on the track leading across the cliff of Te Miko. Their chief development, however, is beyond the northern boundary of the subdivision on the flat top of Tuhinu Hill, and farther north at Croninville and Addison's.

In the Reefton Subdivision the writer knows of no instance where gravels of Pleistocene or younger age have been tilted or faulted. In several localities gravels overlie powerful fault-zones in which Oamaru and Pareora strata are involved. Thus in Burk Creek, a branch of Boatman Creek, Mr. Johnston Howell has sluiced horizontally disposed Pleistocene gravels on a bottom which consists in part of a coal-seam standing vertically between the walls of Palæozoic rocks. Pareora gravels, steeply tilted, occur close at hand, and therefore it is evident that this fault has been active since the Miocene. Other sections proving a similar relationship of the gravels and underlying Tertiaries are to be seen a few chains below Capleston, and again in Soldier Creek, near Reefton; and Morgan* has described and figured an analogous occurrence at Healy Gully, just outside the southern boundary of the subdivision. In these localities one would expect signs of Quarternary faulting if such had occurred; and its absence, combined with the fact that nowhere in the subdivision are Pleistocene or later gravels affected by faults, is presumptive evidence that the movements since the end of the Tertiary have been unaccompanied by differential elevation of the earth-blocks that make up the Reefton Subdivision.

Nature of the Gravels and Conditions of Deposition.

Excellent natural sections of the Pleistocene gravels occur, and those furnished by road-cuttings and sluicing operations provide abundant opportunity for the study of the beds. The gravels are fairly well consolidated; sluicing-faces hundreds of feet in height have been standing for years, nevertheless blasts for loosening the wash are rarely employed. The composition and texture of the gravels vary according to the nature of the rock that furnishes the spoil and the conditions of deposition. Thus in some localities—at Moonlight, at Blackwater, and the hills fringing the Aorere rocks northward to Reefton—the gravels are in great part formed of greywacke and argillite pebbles. On Merrijigs Hill, at Welshman pakihi, and along the eastern side of the graben as far south as the Freeth River granite enters very largely into their composition, while at other localities, chiefly within the rift-valley itself, much schist derived from the rewash of the Pareora conglomerate is to be found. The lower portions of the beds usually consist of well-rolled even-sized gravels, the individual pebbles of which are rarely 4 in. in diameter, and generally only half that size. Decomposition is widespread, and the beds are usually yellowish in colour, while a considerable amount of clayey and sandy matrix is present, and bands of this nature are occasionally developed, to the exclusion of the coarser material. Nevertheless, from a little distance the lower beds give an impression of evenness in texture. In the upper beds, however, this uniformity is wanting; layers of large boulders alternate with fine shingle and sand. Sometimes the stones become very large and angular, thus indicating ice as the transporting agent. Localities that may be mentioned are from Napoleon Hill to the head of Duffer Creek, near Waiuta, and at several points along the track leading from that township to Big River. On the high swampy terrace between the Waitahu and Boatman Creek are

* N.Z. G.S. Bull. No. 13, 1911, p. 74.

enormous masses of porphyritic granite, which could only have been carried to their present position by ice. The huge subangular granite rocks through which the head of Landing Creek takes its way appear to be morainic, but they are possibly part of the talus from the crest of the Brunner Range. The coarse granite wash worked for gold in the upper valley of Welshman Creek contains water-worn boulders of such a size as not even the Buller with its present grade could transport so far from the mountains. "The extended glacier deposits outside the limits of the mountains,"* which, in Westland, Morgan has shown to be due to a great piedmont glacier, have been traced by McKay as far up the Grey valley as Napoleon Hill and Duffer Creek. The present writer has noted glacial material near and beyond Waiuta, occurrences directly in line with the edge of the great glacier as determined by Morgan and McKay, thus indicating its extension northward of the Big Grey. In this locality the mountains which fed the ice of the low country are quite close, and the piedmont glacier may not have extended north far beyond this point. In this connection it may be stated that the gravels of Merrijigs and the vicinity are undoubtedly fluviatile, and not fluvio-glacial. It is probable that the most northerly feeder of the ice-lobe came down the upper valley of the Inangahua, and turned southward over the area now drained by the headwaters of the Alexander and Snowy rivers. In Pleistocene times a great glacier came down the valley of the Waitahu, and ended near Capleston. It is not unreasonable also to assign the morainic-looking gravels of upper Landing Creek to a glacier from the Larry valley, and to consider the coarse gravels of Welshman pakihi as re-sorted from the terminal moraine of a glacier descending the Buller through the Lyell Gorge. On the western side of the Grey-Inangahua valley undoubted moraines occur above the gorges in the valleys of the Te Wharau, Otututu, and Freeth rivers, in addition to a doubtful deposit in the Whitefoord, while the Waitakere river rises in a glaciated trough. In the upper valleys of other large streams draining from the Paparoa Mountains and in the coastal region of the subdivision no traces of Pleistocene glaciation were noted.†

On the road from Blackwater to Waiuta there is clear evidence that the Pleistocene gravels fill drainage-channels which had been excavated to a level lower than that of the present stream-beds. On the Snowy River above the Millerton Claim, and again near the Big Grey Bridge, what look like Pleistocene gravels rise as bluffs from the river flood-plains. On the right bank of the Waitahu, below the bridge on the short track to Capleston, thick layers of gravel may be seen unconformably overlying Upper Miocene beds. Down-stream the surface of contact approaches the river-level, and at a point a little more than a mile from the bridge the Pleistocene gravels form cliffs which rise from a flood-plain a few feet above the river. Thus within the Reefton Subdivision there is evidence in two widely separated localities that between the Upper Miocene and Pleistocene (probably during the latter period) drainage-channels had been cut lower than the present stream-beds. Along the coast there is no evidence that the land at that time stood at a higher level than now, nor would one expect to find traces of such an elevation in a locality exposed to the attacks of the sea.

To account adequately for all the facts it is necessary to postulate that the post-Miocene uplift continued until the land stood higher than at present. During the period of elevation valleys were excavated, and these were not always in the same position as those of the present streams. The main difference, however, is believed to have been in the drainage of the Inangahua-Grey graben, which it is considered at this period was occupied by a single river-system that emptied to the

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* McKay, A.: "Geology of the South-west Part of Nelson and the Northern Part of the Nelson District." Mines Report, C.-13, 1895, pp. 19, 20.

† See, however, N.Z. G.S. Bull. No. 17, 1915, pp. 49, 56, 93, and 113.

sea probably southward of Hokitika. In the chapter dealing with the structure of the subdivision it was pointed out that the graben was floored by a series of elongated earth-blocks having a general pitch to the southward. The upper portions of these blocks are formed of strata of Upper Miocene and probably Pliocene age, and these are unconformably succeeded by the Pleistocene deposits here considered. It may be assumed then that this great structural trough when lifted above sea-level was occupied by a stream, which enlarged the valley it found ready-made for itself. On page 50 is given a table showing the breadth of this valley at various points, as preserved by subsequent infilling by Pleistocene deposits and modified during its re-excavation by recent stream erosion. It will be noted that the old valley rapidly narrows northward, and beyond Landing Creek little or no trace of it remains until Welshman pakihi is reached, where its floor, covered by Pleistocene gravels to a depth of nearly 200 ft., occurs more than 900 ft. above sea-level.

After the formation of the river-valley the land was depressed, and eventually sank until the strand-line was from 500 ft. to 600 ft. higher than at present. In spite of this depression the sea does not seem to have invaded the lower end of the valley—at least, no deposits of this age other than fluviatile gravels have yet been recognized. It is probable that the vast supplies of spoil fed to the river by the glaciers of this period sufficed to aggrade the river-bed and at the same time to maintain the coast-line in its old position. The deposits of this age may then be considered to be for the most part the gravels of the outwash plain from the piedmont ice-sheet, and farther north gravels from the river-trains of the valley glaciers. This view is supported by the nature of the great bulk of the deposits here referred to the Pleistocene, consisting as they do of even-sized and sometimes incompletely rounded stones set in a relatively great amount of sandy and clayey matrix. It is not contended that the land-depression above mentioned brought about a reduction in the intensity of glaciation; indeed, such direct evidence as there is suggests that the greatest extension of the glaciers was at the period of maximum land-depression. Thus the Pleistocene moraines of the ancient Waitahu glacier, and those of the piedmont glacier at Waiuta and Napoleon Hill, overlie the gravels of this age. Glaciers in their retreat frequently leave hollows that are occupied by lakes, and probably the horizontally bedded silts that near Waiuta smother an old land-surface to a depth of from 50 ft. to 80 ft. are deposits in a lake of similar origin. These silts and clays were also noted on the plateau-like country toward the head of the Big River, where, as at Waiuta, they are covered by coarse granitic gravels.

Age and Correlation.

The gravels here considered, although they contain no interior evidence of age, have been placed in the Pleistocene. This has been done because they overlie with great unconformity the Pareora beds, which are regarded as of Upper Miocene age. On the other hand, they are decidedly older than the Recent gravels of the lowlands, and, moreover, were laid down under conditions which have long since ceased to prevail.

These gravels form the chief portion of McKay's Old Man Bottom series. This geologist, although as early as 1874 he had distinguished the occurrence of two conglomerates among the hills between the Inangahua and Mawheraiti rivers—the upper, yellow in colour and composed of argillite, greywacke, and granite, and the lower, blue, containing only mica-schist pebbles "without the slightest fragment of granite in it"*—does not in any subsequent report attempt to separate them. As

* Rep. Geol. Explor. during 1873–74, No. 8, 1877, p. 85.

stated on a preceding page, the conglomerate-bands containing only schist-fragments are interbedded with and form part of the beds classed as the Pareora in this report. All writers are agreed in correlating the beds now under consideration with the Moutere Gravels of Nelson, deposits which it is well known unconformably overlie the Port Hills beds of that district.*

Recent Deposits.

In a preceding chapter the physiographical effects of recent intermittent elevation were discussed, and an attempt was made to correlate the beach deposits and the wave-cut platforms of the coast with the river-terraces of the Grey-Inangahua graben. It was shown that three strand-lines in addition to the present shore are indicated, and that these correspond with the flood-plains and terrace-sets of the river-systems. In the last section it was stated that during or at the close of the Pleistocene a depression of the land had taken place, and that the uplifts of later time did not equal this depression. The beginning of the later movements of elevation is taken to mark the close of the Pleistocene.† In some localities the line of demarcation between deposits of Pleistocene and Recent age is, in the field, difficult to draw, while in others the age of particular gravel-beds is in doubt. In this classification the highest set of marine beach deposits is considered to have been formed during the period of equilibrium between the Pleistocene depression and the Recent elevation. Similarly the high pakihis that are so prominent a feature of the eastern side of the Inangahua valley, and that are developed to a less extent along its western side, are remnants of an ancient flood-plain formed during this period of rest. For the same reason the highest terraces of the Big Grey, lying between Mossy Creek and the Blackwater River, are also placed in the Pleistocene, while other terraces of both the river-systems, though very little less in height, are believed to be ordinary stream-terraces, and not remnants of wide flood-plains. Thus these later terraces are considered Recent, although they probably consist of Pleistocene beds with a thin veneer of later gravels.

Marine Beds.

These differ but little from the similar beds of Pleistocene age. They consist of well-rolled gravels, of which even the smallest pebbles are quite smooth. With them are associated layers of blacksand which, by the action of meteoric waters, has been oxidized to a greater or less extent, and has cemented many feet of the gravels. Beds of unconsolidated sand, usually buff-coloured and containing occasional small stones, occur. Similar beds are accumulating along the present shore-line, the only differences being the slight amount of consolidation and the oxidation of the blacksand. As above stated, they occur along two elevated strand-lines, the highest of which may be termed the "200 ft. strand-line," although deposits occur from 180 ft. to 250 ft. above sea-level. The beds at this level are developed continuously as a narrow strip from the northern boundary of the subdivision to the Fox River. South of the Fox only patches are found until the rock platform jutting into the sea as a blunt promontory between the cliff of Te Miko and Omonehu Creek is reached. North of the Punakaiki a small area of marine gravels occur at this level, while south of it they are developed continuously to Canoe Creek, and again occur as narrow streaks as far south as Barrytown. From 60 ft. to 100 ft. above the

* McKay, A.: "The Baton River and Wangapeka Districts, and Mount Arthur Range"; Rep. Geol. Explor. during 1878–79, No. 12, 1879, p. 131. Park, J.: "On the Geology of the Owen and Wangapeka Goldfields"; Rep. Geol. Explor. during 1887–88, No. 19, 1888, p. 78. N.Z. G.S. Bull. No. 12, 1911, p. 26.

† The use of this criterion leads to the inclusion in Recent deposits of a large portion of the beds classed by McKay and other writers as Pleistocene.

present sea-level, wave-cut benches strewn with beach deposits were noted near St. Kilda, and again south from the Fox as far as Mabel Bay. This line of beach is best seen from Seal Island southward for two miles. The Barrytown coastal plain has evidently been in course of formation continuously since the time of the 200 ft. strand, from which height it slopes gently down to sea-level. James Mackay,* one of the early Wardens, records that no fewer than four old beach-lines may be traced across it. From Canoe Creek it is delimited on the east by a sea-cliff capped by the gravels of the 200 ft. strand-line. Along the base of this the 80 ft. rock bench may occasionally be seen. The narrow coastal plains north of Brighton, and between the Ten-mile and Seventeen-mile bluffs, belong to a very recent slight elevation.

Fluviatile Gravels.

The numerous streams of the subdivision have terraces and flood-plains, wide in the Grey-Inangahua valley and much less extensive in the hills and mountains. Like the Recent marine deposits, the fluviatile gravels of the rift-valley have been profoundly influenced by the intermittent elevations of recent times. Thus the gravels of the present flood-plains of the Buller and Inangahua, from the junction to Landing Creek, belong to the present period of erosion, initiated when the strand-line moved downward from the 80 ft. rock platform. Along the Grey the effect of this uplift is just beginning to be felt by the river as it leaves the subdivision. In the coastal region the Fox, Porarari, and Punakaiki, where they do not flow in gorges, have the flood-plains of this period right to the foot of the range.

The flood-plains which belong to the erosion period represented on the coast by the 80 ft. strand-line are well shown along the Inangahua from Landing Creek to Reefton. In the Grey valley they reach to Willing's Flat on the Big Grey, and taper out on the Mawheraiti near Maimai.

The pause in elevation which permitted the waves to cut so prominent a shelf at the 200 ft. strand-line is represented in the great graben by the wide-stretching terraces of the Grey and Mawheraiti. The so-called plains formed by these terraces are by no means featureless—frequently they are traversed by well-marked terraces; but these are insignificant when compared with the close-cut terrace-steps that divide them from the present flood-plains of the streams. In the Inangahua valley the separation of the flood-plain from the higher terraces is in most places very marked; but sometimes the tendency, common to all terraces, of grading up-stream into the present flood-plain makes separation more difficult than is the case in the Grey valley. Again, the level of these higher terraces is not so uniform as is the case with those of the Grey, for the terrace-series here has not been formed by a stream which long maintained a given river-level. In the coastal region, gravels which may be referred to the erosion period of the 200 ft. strand-line veneer the Blue Bottom beds of the piedmont depression between the Porarari and Bullock Creek. High terraces between the limestone hills and the Paparoa Range, developed in the valleys of the Porarari and the branches of the Fox, belong to this period. For further information in respect to the distribution and history of these gravels the reader is referred to page 46 *et seq.*

Hitherto the gravels of the intermontane valleys have not been considered, but in the upper valleys of all the larger mountain-streams considerable areas of fluviatile and morainic deposits are to be found. These areas are separated from the lowlands by rock-bound gorges of varying depth and difficulty. It has been pointed out in a preceding chapter that the rejuvenation of the streams of the subdivision, due to the last uplift, affects only the coastal region and part of the Buller basin; and the

* Wardens' reports, 1881, H.-26, p. 20.

writer believes that the lower gorges of the mountain-streams flowing to the rift-valley belong to the elevations that brought the 500 ft. and 200 ft. erosion periods to a close. The gravel-deposits of the upland valleys, therefore, although frequently no higher than the present flood-plains of the streams in these localities, are mapped as belonging to the 500 ft. erosion period, while doubtless also gravels of true Pleistocene age are present.

Glacial and Fluvio-glacial Deposits.

Extensive intermontane glacial deposits, of an age undoubtedly younger than the Pleistocene as defined on a previous page, occur within the subdivision. The best example is furnished by the moraine of the ancient Inangahua glacier, which extends from Stevenson Flat nearly to Welsh's farm, and lies in a valley hundreds of feet below the Pleistocene gravels capping the hills of the basins of the Alexander, Snowy, and Big rivers. Morainic material also occurs at many places higher up the same valley, deposited as the glacier shrank. In that portion of the basin of the Waitahu within the subdivision the writer saw no undoubted moraine of this age, but much of the gravels near the forks is probably fluvio-glacial, while the wide upper valleys have every appearance of having been modified by ice-action. In the north branch of Larry's, just on the subdivision boundary, occur huge granite boulders which are almost certainly ice-borne, but these may well be of Pleistocene age. At the sources of many of the mountain-streams are ice-cut tarns; and some of the loose angular material found so frequently in these localities may be moraine, although much of it doubtless grades into talus. Such deposits may be of very recent origin, although at present no permanent snowfields or glaciers exist in the subdivision.

Sand-dunes.

The only deposit which may be referred to the action of the wind occupies a few acres immediately to the south of the mouth of the Porarari. The greater part is grassed, and may perhaps be a raised beach, but to the west a low but undoubted foredune faces the sea.

Talus.

Scree deposits are exceedingly common on the mountains above the bush-line, and with these should also be considered the low ridges on the south-eastward-facing slopes of Mount Raoulia, which, as already stated, are winter-talus accumulations. The vast slip of which the débris embarrasses the Ototutu for many miles, the similar occurrence in a small branch discharging into the gorge of the Te Wharau, and the older slip at the head of the Blackball are undoubtedly conditioned by the existence of fracture-zones near these localities.

IGNEOUS ROCKS.

Distribution.

Igneous rocks of various types cover 272¼ square miles in the Reefton Subdivision, or rather more than a quarter of the whole area. They occur in three main masses, forming the bulk of the Paparoa, Brunner, and Victoria ranges. In addition, these resistant rocks cover a portion of the Orikaka uplands, and outcrop from beneath Tertiary strata at various points along the coast. The rocks themselves consist of granites of various types, gneiss, and quartz-porphyry, while, in addition, dykes of acid, intermediate, and basic composition traverse the plutonic and adjacent sedimentary rocks.

The oldest rock is undoubtedly the gneiss that forms the western portion of the Paparoa Range from the Fox River northward. South of the Fox its western edge is flanked by Tertiary breccia and conglomerate. Granite limits the gneissic rocks on the east. The junction on this side, however, was nowhere noted, and the rocks have not been separated on the maps. Roughly, it may be stated that the upper valley of the Otututu, which is excavated along a fracture-zone, separates the two rocks, Mount Uriah and the ridges to the west of the valley being formed of gneiss, while the mountains on the east side are granite. Farther south mounts Marshall and Johnston are of gneiss, which also outcrops toward the head of Mirfin Creek, the lower outcrops being of granite. In the Freeth River the plutonic rocks are gneiss, which in the lower part of the gorge is penetrated by large granite dykes, while in the Pike the rock is entirely granite, which sometimes becomes gneissoid. Another area of gneiss outcrops beneath the Miocene strata at St. Kilda, and continues along the shore-line to beyond the subdivision, forming the shelf-like plateau known as Tuhinu Hill. It should be noted that a contact of Palæozoic sediments and of gneiss was nowhere observed.

By far the greater proportion of the remaining igneous rocks of the Paparoa Range is granite, often granitoid in texture, and also frequently porphyritic. The main mass stretches southward from the Buller-Mokihinui Subdivision, forming the eastern ridges of the Paparoa Range as far south as the Otututu River. In the southern portion of these mountains several isolated areas of granite occur, the largest of which outcrops in the Pike, Slaty, and Granite streams. A smaller area occurs on the western flank of the range at Barrytown, reaching from Fagin Creek on the south to Clarke Creek on the north, a distance of over two miles. Another very small exposure outcrops in a right-hand branch of the Punakaiki, in the heart of the range; while a still smaller fragment, involved in the Lower Buller fault-zone, appears on the edge of the range in Dilemma Creek. With the exception of the last-mentioned occurrence, all these areas are of rock obviously intrusive into the greywacke and argillite of the Aorere Series; and since the contact surface of such injections are exceedingly irregular, the boundaries of the various exposures as mapped are very rough, and little better than guesswork. The occurrence of acid dykes south of the Seventeen-mile Bluff indicates that the granite batholith underlies the sedimentary rocks at least as far south as this, since dykes of this nature seldom penetrate the overlying rock far from their parent mass. Along the coast-line the Gentle Annie Rocks, a name given to an exceedingly rugged portion of the shore about two miles in length, is formed of granite.

The granite bosses forming the Brunner and Victoria ranges, though apparently separated by Aorere rocks, are directly connected to the eastward of the subdivision, and, in addition, undoubtedly exist beneath the ancient sediments, through which, indeed, at many points they appear, exposed by denudation. The basin of Larry Creek in its upper part is fairly free from faults, and affords excellent opportunities for the study of contact phenomena, which may also be observed along the gorge of the Buller from Lyell eastward, for here the road follows the contact fairly closely. The granite area developed west of Welshman pakihi is probably separated from that to the east of the Buller only by a veneer of Tertiary rocks, and, if so, must be considered a part of the Brunner mass.

Quartz-porphyry in direct continuation with that of the Buller-Mokihinui Subdivision occurs in the Inangahua Survey District. The principal outcrops are in the gorges of the Orikaka River and Welshman Creek; but minor outcrops associated with greywacke, and evidently part of the penetration fringe of the intrusion, occur at the junction of the Inangahua and Buller, opposite the mouth of Welshman Creek, and again near Burley's coal-mine east of Berlin's.

Dykes of pegmatite, aplite, microgranite, and granite-porphyry are common in the granites of the subdivision. They rarely occur in the sedimentary rocks, and then only in the metamorphic aureole next the igneous intrusion. The only exceptions—and these are probably more apparent than real—are the pair of aplitic dykes outcropping on the beach a little south of the Seventeen-mile Bluff; and as these traverse slightly altered greywacke it is probable that the subjacent stock is close beneath. A very large mass of garnet-bearing pegmatite occurs in the headwater valley of the Otututu, but whether this is in the nature of a huge dyke or of an irregular igneous body was not ascertained.

Dykes of intermediate composition and of many types are by no means rare in the granites, but seem to be confined to them and their immediate neighbourhood. A great mass of quartz-diorite occurs in Welshman Creek. Its exact relationship could not be made out, but it is apparently a large mass in close connection with the granodiorite of that locality, rather than a regular dyke filling a fissure.

Basic dykes are also a common feature of the subdivision, and those traversing the igneous rocks are of many types. Those occurring in the sedimentary rocks, however, are of one kind only—diabase; and this rock was found neither *in situ* in the main plutonic masses nor as shoad in streams draining country composed entirely of such rocks. Dykes of this rock are most common in the lode-bearing zones of the Aorere rocks—in fact, they are a constant feature of them. Nevertheless, they also occur where no quartz veins were observed, and appear to have a regional distribution.

The age of the plutonic rocks of the subdivision is a matter on which no very definite statement can be made. The various intrusions of plutonic rock are closely related to each other chemically, and the two main masses of the Paparoa and Brunner-Victoria mountains form composite batholiths*: they may, indeed, be parts of the same batholith. If this hypothesis be accepted it may be supposed that the first group of injections is represented by the gneiss and the second by the granites. This theory requires that the first injection of relatively cold pasty material was made in such a manner as to produce a gneissoid structure, and was followed soon afterwards by a second injection of decidedly hotter and chemically similar material under conditions that only occasionally produced a gneissoid structure, the dioritic rocks and the quartz-porphyry being differentiates of the mass of the latter injection. This will also explain why the gneiss is practically devoid of dykes except where adjoining the granite, while the granite contains them in great number. A second and more plausible hypothesis postulates that the gneisses are very much older than the other plutonic rocks, that they were formed under different conditions, and have been subjected to stresses other than those that have affected the granites, &c. It is suggested that they are older than the Aorere Series,† and that they formed the epicontinental shelf on which these sediments were deposited. Nowhere, however, within the subdivision was an actual contact between gneiss and the Palæozoic sediments observed, although at numerous points the junction of these latter rocks with the intrusive granites and quartz-porphyry may be studied. The Reefton Subdivision thus affords positive evidence that some of the granite is younger than the Aorere rocks and the gneisses, but no conclusive evidence concerning the relative age of the gneiss and the Palæozoic sediments.

The intrusive plutonic rocks of the subdivision must be correlated with similar rocks in North Westland and West Nelson as a whole. Hutton‡ also correlates them with the eruptive granites of Western Otago and Stewart Island. Some years previously this geologist also separated the gneisses and schists of his Manapouri System of Archæan age from these intrusive rocks,§ and in this he is followed by Park|| and Marshall.¶

* Daly, R. A.: "Geology of the North American Cordillera at the Forty-ninth Parallel." Memoir 38, Dept. of Mines, Canada, 1912, p. 722.

† *Cf.* N.Z.G.S. Bull. No. 17, 1915, p. 97.

‡ "The Geological History of New Zealand." Trans., vol. xxxii, 1900, p. 164.

§ "Sketch of the Geology of New Zealand." Q.J.G.S., vol. 41, 1885, p. 215.

|| Geology of New Zealand, 1910, pp. 30, 41.

¶ Geology of New Zealand, 1912, pp 175, 188.

Gneisses have also an extensive development in North Westland, and Morgan* considers some of them of greater age than the intrusive granites. Park† long ago noted that the stratified rocks of the Pikikiruna Range, which he considered of Aorere age, rest upon a denuded surface of granite, a conclusion, however, denied by Thomson.‡ Again in the Parapara Subdivision, in conglomerates of the Haupiri Series, considered to be of Devonian age, pebbles derived from acidic igneous rocks have been noted by Bell, Webb, and Clarke.§ Marshall|| has described granites and porphyries from a Triassic conglomerate in the Nelson district, an occurrence of which the significance seems first to have been pointed out by Park,¶ while Cox** had long before noted a similar boulder-bed in rocks of approximately the same age in the Southland district. In this latter region, according to Marshall,†† the Maitai sediments, of which the oldest are of Triassic age, appear to be unconformable to the Manapouri System, which contains much plutonic rock and is of supposed Archæan age. From the above statements it may safely be concluded that acidic plutonic rocks occur in New Zealand that are certainly older than the Devonian and probably older than the Silurian (Aorere).

There is another line of argument by which this subject may be approached, that which uses the structural features as a basis. The association of extensive igneous intrusions with orogenic movements is well known. The latest movement of this kind affecting the West Coast occurred in Late Mesozoic times, when the vast thickness of beds in a geosynclinal, filled during the Triassic and Jurassic periods, were folded and overthrust against the foreland of which the Reefton Subdivision forms a part. In addition to the granite bosses of North Westland, with which the intrusive granites of this subdivision must be correlated, and which are probably the result of this period of mountain-building,‡‡ are small areas of granite and acid diorite occurring near the head of the Maruia in the marbles and schists developed along the great Alpine overthrust. These rocks are not in the least gneissoid, and are not sheared or crushed. Mackay's Bluff, near Nelson, may also be quoted. Thus it is probable that some of the acid igneous rocks of the West Coast were intruded subsequently to the mountain-folding. On a later page an attempt is made to show that the auriferous veins of the subdivision are a product of the after-effects of the igneous intrusions. Now, the main mineralized belt may be traced southward until the lodes actually traverse the folded rocks of the Alps. Thus, providing the premises above stated are sound, the conclusion is probable that the folding of the mountains was prior to the intrusion of some of the granite. From this discussion the writer tentatively concludes that the true gneisses are of pre-Aorere age, and that the intrusive granite is of Late Mesozoic age.

In regard to the age of the dykes, the evidence is of a most meagre description, and much of what can be said must be regarded as pure speculation. The acidic dykes generally are regarded as being little younger than the granite they penetrate, and to a certain extent the same is true of those of intermediate composition. These, the vogesites, quartz-diorites, and feldspar-porphyries, have field relations similar to those of the pegmatites.

The basic dykes, which present a much more interesting problem, probably were injected during two periods—the one during the principal act of the Mesozoic intrusion

* N.Z. G.S. Bull. No. 6, 1908, p. 82.

† " On the Geology of Collingwood County, Nelson." Rep. Geol. Explor. 1888–89, No. 20, 1890, p. 231.

‡ 7th Ann. Rep. N.Z. G.S., C.–2, 1913, p. 132.

§ N.Z. G.S. Bull. No. 3, p. 71.

|| " Boulders in a Triassic Conglomerate, Nelson." Trans., vol. xxxvi, 1904, pp. 367–71.

¶ " On the Geology of the Owen and Wangapeka Goldfields." Rep. Geol. Explor. 1887–88, No. 19, 1888, p. 84.

** " Report on the Geology of the Hokanui Ranges, Southland." Rep. Geol. Explor. 1877–78, No. 11, 1878, p. 47.

†† Geology of New Zealand, 1912, p. 174.

‡‡ Morgan, P. G. : N.Z. G.S. Bull. No. 6, 1908, p. 71.

and the other during the Late Tertiary. The dykes of dolerite or diabase are constantly associated with the auriferous lodes, with the strike of which they frequently conform. Although the diabasic rocks are readily recognized in the field, no instance in which they cut other igneous rocks has been observed,* nor are they known to occur as pebbles in streams exclusively draining granite regions. Cox† notes the occurrence of a dyke similar to the diabase in the North Star tunnel near the head of Murray Creek, in the greywacke east of Lake Mapourika in South Westland. Bell, Webb, and Clarke‡ mention the occurrence of diabase and gabbroid rocks in the Parapara Subdivision, where they occur, however, only in connection with the Palæozoic sediments. Morgan and Bartrum§ describe and figure a dolerite collected as a fragment in greywacke débris from the Buller-Mokihinui Subdivision. Thus it is probable that the diabasic dykes are older than the intrusive granites of the West Coast region.

If comparison be made between the dolerite and rocks of similar silica percentage penetrating the granite|| it will be found that in the former the alumina and alkali content are decidedly lower and the lime percentage decidedly higher, while iron is usually lower and magnesia higher than in the case with the dykes traversing granite. From this it is an obvious inference that the two sets of dykes are not connected, and were probably intruded at different periods. There is not one important mine in the Reefton district within the workings of which or near which a diabase dyke has not been discovered. On the other hand, certain diabase dykes are near no quartz lode, a notable example being furnished by the largest mass so far discovered—that outcropping on the track to Kirwan Hill near the head of Boatman Creek, and apparently forming a large plug. In the Mount Radiant Subdivision, where the lodes are probably of approximately the same age as those of Reefton, no diabase dykes are recorded. In a later section an attempt is made to show that the quartz lodes of the subdivision are in the closest connection with the pegmatitic veins, which are universally admitted to be genetically related to granite-magmas. Thus the general association of the diabasic dykes and the quartz lodes is physical, and not genetic. It has arisen because the dykes and the veins occupy fissures in a fracture-zone older than both.

The mode of occurrence of the diabasic dykes and the granites is most readily explained by means of the " basaltic substratum " theory of R. A. Daly.¶ This hypothesis, which is supported by a great mass of facts, postulates among other things that the magma of any great intrusion is, during the initial stage, basaltic in nature, and consequently any dykes formed during its injection have a like composition, while the granite and its satellitic igneous rocks arise from the differentiation of the original basaltic magma. The diabases of the subdivision closely resemble each other in composition, far more than do any other similar series of dykes on the West Coast. They resemble in composition the average basalt as given by Daly,** and calculated from nearly two hundred analyses.

The other basic rocks of the subdivision have the composition of pyroxenite, camptonite, and basic basalt. The first-mentioned rock forms two large dykes in Mirfin Creek, a branch of the Otututu, in which river, as also in the Inangahua and Waitahu, boulders of a similar rock occur. The dykes are obviously formed almost entirely of hornblende, and have the composition of websterite, a type of rock hitherto

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* Hutton in " Note on the Geology of the Country about Lyell," Trans., vol. xxii, 1890, p. 389, records the occurrence of a dyke of " hornblende dolerite " in granite. From his description the rock is evidently a lamprophyre, and not a diabase.

† " Report on Westland District." Rep. Geol. Explor. 1874–76, No. 9, 1877, p. 77.

‡ N.Z. G.S. Bull. No. 3, 1907, p. 70 and maps.

§ N.Z. G.S. Bull. No. 17, 1915, p. 104.

|| The dyke, the analysis of which is given as No. 13 on p. 110, is excepted.

¶ " Geology of the North American Cordillera at the Forty-ninth Parallel." G.S. of Canada, Memoir No. 38, 1912, p. 780. ** *Op. cit.*, p. 685.

reported only from north-west Otago* and the Dun Mountain,† in close association with the ultra-basic intrusions of those districts. Possibly all these occurrences may be correlated in time, but the only legitimate inference is that in these localities crustal stresses found relief by the intrusion of dykes when the injected magmas had reached a similar stage of differentiation. If Daly's hypothesis—that magmas as initially intruded are basaltic, and that the first differentiate is ultra-basic and is separated long before any part of the mass approaches granite in composition—be correct, the pyroxenite dykes in the gneiss of Mirfin Creek strongly suggest that this gneiss is older than the intrusive granite of the subdivision.

Long ago the presence of volcanic rocks in association with Tertiary limestone was noted by Cox‡ at the Abbey Rocks and near the Paringa River, in South Westland. The one sample the writer has seen of these rocks is that of a fine-grained lava containing a great deal of olivine. Bell and Fraser§ and Morgan|| note a similar association of limestone and volcanic rock at Koiterangi Hill, ten miles south of Hokitika. The latter geologist also reports the existence of basic lava in the Blackball district,¶ probably in connection with Tertiary strata. Pebbles of a basic effusive rock were observed in the beds of several streams draining from the Paparoa Range, notably in the Punakaiki, Otututu, and Te Wharau rivers. Dykes of camptonite traverse the Hawk Crag breccia in the Buller-Mokihinui Subdivision.** The correlation of the camptonites in the granites with the olivine-basalt of Koiterangi Hill, first made by Bell and Fraser,§ received some confirmation by the last-mentioned discovery, and is regarded by the writer as decidedly probable. These more or less alkaline ultra-basic rocks are generally considered to be the last differentiation-product of an igneous magma. The rocks have probably all been injected or extravasated during the same period of crustal movement, the differences in composition having arisen from the various occurrences having been derived from bodies of molten rock that, although differentiation-products of the same initial magma, have become separated by the irregular freezing of the mass, and have not reached the same stage in the process of differentiation.

Petrology and Composition.

Plutonic Rocks and Acid Dykes.

The plutonic rocks of the subdivision differ in no essential respect from the similar rocks of the Buller-Mokihinui Subdivision; and for a petrological description of the granites, gneisses, diorite, and quartz-porphyry the reader is referred to that publication. Similar remarks apply to the pegmatites and aplites. Dykes of granite-porphyry with a micrograniti groundmass also occur. Sometimes the phenocrysts are entirely suppressed, when a microgranite results. In these and related rocks the structure is never granophyric, as in many of the North Westland†† rocks of this type, but always microgranitic. Analyses of the rocks here mentioned are given below (page 109, Nos. 1 to 8).

Feldspar-porphyrite.

Large intrusive masses of feldspar-porphyrite occur in the basin of Deep Creek (Waitahu Survey District), one near the junction of Willis Creek and the other in

* Marshall, P.: "Geological Notes on the Country North-west of Lake Wakatipu." Trans., vol. xxxviii, 1906, p. 564.
† N.Z. G.S. Bull. No. 12, 1911, p. 30.
‡ "Report on Westland District." Rep. Geol. Explor. during 1874–76, No. 9, 1877, pp. 81–83.
§ N.Z. G.S. Bull. No. 1, 1906, p. 82. || N.Z. G.S. Bull. No. 6, 1908, p. 138. ¶ N.Z. G.S. Bull. No. 13, 1911, p. 81. ** N.Z. G.S. Bull. No. 17, 1915, p. 104. †† N.Z. G.S. Bull. No. 13, 1911, p. 79.

the upper valley of Golden Lead Creek, while a dyke of the same material 6 ft. wide was cut in No. 9 level (south) of the Big River Mine. Boulders of similar rock occur in the beds of Flaxbush and Dee streams (Inangahua Survey District). All the outcrops of this rock were decidedly decomposed, and for this reason a sample from the dyke in the Big River Mine was selected for analysis (No. 9, page 109). This, however, has evidently been altered by lode-forming solutions, which have added potash, carbon dioxide, and water, and abstracted silica and lime.

In hand-specimens the rock shows abundant tabular feldspar crystals, up to half an inch across, and a few small phenocrysts of augite and mica set in a fine-grained greyish-green matrix. Under the microscope the feldspar is seen to be sharply idiomorphic and strongly zoned, and ranges through various grades of labradorite. The other phenocrysts consist of brown biotite showing resorption borders, and augite altered to hornblende and epidote. The groundmass is fine-grained and apparently holocrystalline, and consists essentially of feldspar in small prisms, with a little interstitial chloritic material and perhaps quartz. Grains of iron-ore are fairly abundant, and, judged from the occurrence of leucoxene close to many of them, probably consist of ilmenite.

Lamprophyres.

Mica- and hornblende-lamprophyres are represented in the pebbles of the streams. The range of varieties is nearly complete, and, except in the case of the camptonites, specimens may be obtained showing that the rocks are closely related to each other. Doubtless, also, pebbles of different types were yielded by one and the same dyke. No unusual features are exhibited, and sections will not be described in detail. Typical minettes and kersantites are rare, but the hornblende-bearing varieties are common, and show gradations into true vogesites and spessartites on the one hand and relationships with the mica-diorites on the other. Frequently the spessartites contain stout well-shaped phenocrysts of greenish-brown hornblende, and a similar feature is exhibited by some odinites, which differ from the spessartites only in that the hornblende of the groundmass is developed more abundantly, and in slender sharply idiomorphic prisms. All the spessartites contain diopside in grains and aggregates, and sometimes this mineral occurs in greater amount than the hornblende.

Lamprophyric rocks were found *in situ* at two points only: one a dyke of hornblende-minette a few inches thick occurring in the fine-grained granite exposed in the cutting on the Reefton–Maruia Road, a few chains without the subdivision; the other apparently an irregular segregation of mica-vogesite on the northern slopes of the western peak of Mount Albert (Waitahu Survey District). The first-mentioned rock consists essentially of feldspar and mica, with subordinate greenish-brown hornblende. Diopside, sphene, apatite, and iron-ores are accessories. The feldspar is chiefly orthoclase, with a little oligoclase, while the hornblende consists of ragged prisms containing zonally distributed inclusions of iron-ore. The rock from Mount Albert is similar, but contains a greater proportion of hornblende and plagioclase. Samples of these rocks were analysed (Nos. 10 and 11, pages 109 and 110).

Camptonites and Basalts.

Typical camptonites, showing deep-brown idiomorphic hornblende in two generations with subordinate augite and occasional phenocrysts of decomposed olivine, occur as pebbles. A dyke of camptonite, crushed by fault-movements subsequent to its consolidation, occurs in the gorge of the Frecth River (Waiwhero Survey District). This is a true augite-camptonite, and very closely resembles the dykes of this rock cutting the granite and Tertiary breccia in the basin of the Blackwater River.* Sections show

* N.Z. G.S Bull. No. 17, 1915, p. 104.

that the rock from both localities consists chiefly of violet pleochroic augite in two generations, with a small quantity of decomposed plagioclase for a base. Olivine in large crystals also occurs, as well as an insignificant number of small deep-brown hornblende laths in the matrix. Iron-ore is very abundant, and occurs as grains in the groundmass or as lattice-works of skeleton crystals. Pebbles of a similar rock occur sparingly in the gravels of the Inangahua and Larry rivers. The numerous small idiomorphic augites in the groundmass of the rock from the latter stream are altered to green hornblende, while no phenocrysts are developed.

The dykes in the Freeth and Blackwater rivers undoubtedly belong to the same series of injections. They occur in the same fracture-zone, in the intermediate portion of which, along the intermontane valley of the Otututu, pebbles of similar augite-camptonite are to be found. Thus the whole series must be considered of post-Eocene age, and, as already stated, there is a strong probability of the connection of these dykes with the effusive rocks of the West Coast (page 106). Pebbles of olivine-basalt are abundant in the bed of the Punakaiki River, and also occur in the Porarari and Te Wharau rivers. Sections exhibit large crystals of olivine and augite, while smaller ones of augite and labradorite are numerous. The groundmass is micro-crystalline, and is composed of a very fine-grained felt of feldspar and pyroxene prisms, with much magnetite-dust. Some sections also show a little brownish glass.

Hornblende Rock.

Large dykes of a rock composed almost entirely of hornblende occur in Mirfin Creek, a branch of the Otututu, while boulders of a similar rock are to be found in the gorge of the latter stream and also in the beds of the Inangahua and Waitahu rivers. The fissure containing one of the dykes obviously has been active since the consolidation of the rock, and along the plane of movement the hornblende rock has been altered to a mica-schist. In hand-specimens the normal dyke-rock is seen to consist almost entirely of hornblende, with a small quantity of leucocratic mineral between the crystals. Sections show the rock to be made up essentially of pale-green hornblende, with a little plagioclase. The hornblende is pleochroic in green and yellowish-brown tones, and exhibits sometimes schillerization and always the reedy structure characteristic of uralite. In all sections examined a little brown mica was present, intergrown with the hornblende, and in the micaceous marginal facies of the dyke the mica becomes predominant over the amphibole. Pyrite occurs in small grains, but iron-ores are not abundant. Although the rock contains over 2 per cent. of chromium sesquioxide, chromite was not definitely recognized. A pebble of slightly altered websterite, consisting essentially of augite and hypersthene with a little plagioclase and mica, was found in the Otututu River.

Analyses Nos. 13 and 14, page 110, show that the typical dyke-rock and its micaceous facies have nearly the same composition; perhaps a little potash has been introduced during the alteration. The rock is evidently an altered pyroxenite, and in composition more closely resembles websterite than any other member of that family.

Diabases.

Diabasic dykes are common in the Aorere sediments of the Reefton Subdivision. No unusual types were found, the great majority of the dykes consisting essentially of augite and plagioclase (andesine to labradorite) with accessory iron-ore, and exhibiting ophitic structure. W. A. MacLeod* has described the rock from the large intrusive

* "Notes on a West Coast Dolerite." Trans. vol. xxxi, 1899, p. 487.

mass on the flanks of Mount Kirwan; a similar rock, somewhat weathered, was examined by Morgan and Bartrum*; while Hutton† has described a chlorite-schist from Specimen Hill that is undoubtedly a dyke-rock crushed by earth-movements, and altered by lode-forming solutions. Mica is occasionally developed, as in the large dyke at the Seventeen-mile Bluff (Temiko Survey District), while, where the rock has been subjected to pressure, as in the vicinity of the quartz veins and in the dyke in McConnochie Creek (Waitahu Survey District), the augite is altered to hornblende, the rock then becoming the epidiorite of some writers.

Five analyses were made of these rocks, of which two were altered—that from Moonlight Creek by atmospheric weathering, and that from the Blackwater Mine by hydrothermal solutions. The rock from Mount Kirwan is decidedly more acid than the samples from other localities, a result probably due to differentiation in the great mass of diabase there intruded.

Hornblende-granulite.

Pebbles of a hard dense rock that on fresh fracture is glistening and dark-green, and sometimes shows an indistinct banding, occurs sparingly in the gravels of the Inangahua River and Slab Hut Creek. Sections show that the rock is a hornblende-granulite, consisting essentially of acid plagioclase, quartz, hornblende, and garnet. The structure is granulitic; and the garnet, which does not appear in all sections, exhibits the centric arrangement so typical of this rock.

Granulites are generally considered to have been formed from igneous rocks by dynamic metamorphism, and it is noteworthy that pebbles have been found only in the beds of streams that have traversed areas of Upper Miocene conglomerate. This rock, as already stated, is almost entirely composed of fragments of schist that must have been derived from the intensely folded zone of the Alpine chain.

Analyses of Igneous Rocks of the Reefton Subdivision.

—	(1.)	(2.)	(3.)	(4.)	(5.)	(6.)	(7.)	(8.)	(9.)	(10.)
Silica (SiO_2)	72·40	68·50	76·25	75·05	72·42	65·55	52·07	45·78	48·62	57·50
Titanium dioxide (TiO_2) ..	0·77	0·80	0·12	0·07	0·02	0·69	1·23	1·26	0·81	0·92
Alumina (Al_2O_3)	12·56	14·35	14·06	14·74	15·61	16·77	17·25	19·18	22·32	18·23
Ferric oxide (Fe_2O_3)	nil	1·60	0·48	0·16	nil	2·24	6·16	3·28	1·08	nil
Ferrous oxide (FeO)	4·03	3·71	0·58	0·36	0·79	1·58	5·40	9·14	3·74	5·81
Manganous oxide (MnO) ..	0·50	0·05	0·02	0·10	0·01	0·06	0·20	0·17	0·15	0·10
Lime (CaO)	2·09	2·11	1·75	0·78	0·27	2·90	8·12	8·20	2·12	5·45
Magnesia (MgO)	1·87	0·93	0·18	0·05	0·11	2·57	2·92	6·03	2·69	3·80
Potash (K_2O)	1·95	3·83	2·97	4·02	8·53	1·96	1·09	1·32	5·85	1·73
Soda (Na_2O)	2·14	2·91	3·12	4·32	1·92	3·58	3·18	2·27	1·82	3·15
Phosphoric anhydride (P_2O_5) ..	0·09	0·29	nil	0·04	nil	0·06	0·78	0·73	0·25	0·30
Sulphur trioxide (SO_3)	0·08	0·14	0·15	0·07	0·13	0·03	0·20	0·17	0·22	..
Carbon dioxide (CO_2)	nil	nil	nil	nil	nil	nil	0·02	nil	4·63	0·50
Water below 100° C.	0·15	0·11	0·12	0·20	0·04	0·55	0·14	0·38	1·74	0·12
Combined water	1·25	1·05	0·53	0·41	0·60	1·28	1·12	2·64	3·61	1·48
Chromium sesquioxide (Cr_2O_3) ..	..	..	..	..	..	..	..	..	..	..
Iron (Fe)	..	..	..	..	..	..	..	..	..	..
Sulphur (S)	..	..	..	..	..	..	..	..	..	..
Iron pyrites (FeS_2)	..	..	..	..	..	..	..	..	..	1·12
Totals	99·88	100·38	100·33	100·37	100·45	99·82	99·88	100·55	99·65	100·21

* N.Z. G.S. Bull. No. 17, 1915, p. 104.

† "The Eruptive Rocks of New Zealand." Jour. Roy. Soc., N.S.W., vol. xxiii, 1889, p. 130.

Analyses of Igneous Rocks of the Reefton Subdivision—*continued.*

——	(11.)	(12.)	(13.)	(14.)	(15.)	(16.)	(17.)	(18.)	(19.)	(20.)
Silica (SiO_2)	52·30	42·05	52·10	50·40	53·60	45·25	44·60	42·32	39·30	49·06
Titanium dioxide (TiO_2) ..	3·46	1·92	0·89	0·93	3·53	3·00	3·73	3·35	4·34	1·36
Alumina (Al_2O_3)	16·29	14·35	4·41	6·01	13·25	16·23	17·41	13·78	14·04	15·70
Ferric oxide (Fe_2O_3)	3·20	3·64	3·20	1·12	2·32	2·56	2·00	1·85	2·40	5·38
Ferrous oxide (FeO)	7·09	8·96	6·84	9·00	7·48	10·30	11·22	12·02	9·22	6·37
Manganous oxide (MnO) ..	0·07	0·30	0·20	0·10	0·15	0·13	0·12	0·13	0·12	0·31
Lime (CaO)	6·90	7·45	8·94	5·00	9·30	8·60	7·90	4·52	8·24	8·95
Magnesia (MgO)	4·17	13·98	17·75	17·74	5·15	6·98	6·58	6·73	5·29	6·17
Potash (K_2O)	2·44	1·31	0·44	3·44	1·09	1·40	1·07	1·24	1·03	1·52
Soda (Na_2O)	1·38	3·16	0·84	0·26	1·87	2·46	2·68	1·96	2·18	3·11
Phosphoric anhydride (P_2O_5) ..	0·25	0·83	0·09	0·06	0·15	n.d.	n.d.	n.d.	0·20	0·45
Sulphur trioxide (SO_3)	0·11	0·10	?	0·11	0·24	..	..	..	0·20	..
Carbon dioxide (CO_2)	nil	0·76	nil	nil	nil	nil	nil	6·93	8·54	..
Water below 100° C.	0·45	0·32	0·08	0·11	0·76	0·35	0·27	0·36	1·02	..
Combined water	2·23	0·99	1·67	2·95	1·47	2·40	2·40	4·82	4·26	1·62
Chromium sesquioxide (Cr_2O_3) ..	..	..	2·00	2·44	..	..	..	..	..	..
Iron (Fe)	..	..	0·28	..	..	..	..	..	..	..
Sulphur (S)	..	..	0·32	..	..	..	..	..	..	..
Iron pyrites (FeS_2)	..	..	..	..	..	0·25	0·48	0·35	..	..
Totals	100·34	100·12	100·05	99·67	100·36	99·91	100·46	100·36	100·38	100·00

Analyses.—The rocks of which analyses are given in the preceding table are as follow :—

(1.) Fine-grained granite in road-cutting on the Reefton-Maruia Road, a few chains without the subdivision, Rahu Survey District.

(2.) Medium-grained granite on track at Mabel Bay, Brighton Survey District.

(3.) Vein a few inches thick of coarse pegmatite in No. 2.

(4.) Small vein of microgranite in porphyritic granite, Mount Albert, Waitahu Survey District.

(5.) Large mass of pegmatite containing garnet and showing graphic structure, Otututu River, Maimai Survey District.

(6.) Dyke of granite-porphyry 6 ft. wide in granite, McMahon Creek, Maimai Survey District.

(7.) Diorite in granodiorite, Welshman Creek, Inangahua Survey District.

(8.) Diorite occurring in great quantity in talus beside the Reefton–Maruia Road, near the boundary of the subdivision, Waitahu Survey District.

(9.) Dyke 6 ft. wide of feldspar-porphyry, No. 9 level south, Big River Mine, Waitahu Survey District.

(10.) Small dyke of hornblende-minette in (1).

(11.) Irregular segregation of mica-vogesite, Mount Albert, Waitahu Survey District.

(12.) Basalt, loose boulder, Punakaiki River, Waiwhero Survey District.

(13.) Hornblende rock, 10 ft. dyke in gneiss, Mirfin Creek, Mawheraiti Survey District.

(14.) Mica rock, marginal facies of (13).

(15.) Large plug of diabase on track to Kirwan Hill, Reefton Survey District.

(16.) Diabase (epidiorite), McConnochie Creek, Waitahu Survey District.

(17.) Mica-diabase, Seventeen-mile Bluff, Temiko Survey District.

(18.) Diabase, altered by hydrothermal action, 30 ft. below No. 3 level, Blackwater Mine.

(19.) Diabase, 1 ft. thick, near forks of Moonlight Creek, Waiwhero Survey District.

(20.) Average basalt, calculated from 198 analyses. R. A. Daly, " Geology of the North American Cordillera," 1912, page 685.

PERIODS AND DIRECTIONS OF EARTH-MOVEMENTS.

As has been pointed out on a preceding page,* the chief folding affecting the Aorere rocks of the Reefton Subdivision has a north-north-east direction. This agrees with the north-north-east strikes observed by Park† in the Owen-Wangapeka district, and the "nearly north and south" folding (shown on the map accompanying as magnetic north and south) noted by McKay‡ in the Mount Arthur district. To the westward of these localities the strikes as a whole are west of north. Thus in the mountainous country between the Aorere and Takaka rivers the trend of the rocks as a whole varies between north-north-east and north-west.§ Again at the southern end of the Paparoa Range,|| in the Buller-Mokihinui Subdivision,¶ and at Ross** the strikes in general are west of north. Apparently the Palæozoic rocks of the West Coast have been subjected to two series of folding, the one producing north-north-east strikes over a well-marked belt of country from Reefton northward to Separation Point; the other, less definite, affecting the rocks to the westward of this zone, and producing north-westerly strikes. Neither of these directions corresponds with the trend of the plications of the Alpine chain, which are of Late Mesozoic date and presumably quite distinct from and younger than the foldings of the rocks to the west of the great series of overthrusts.

The Tertiary stresses appear to have found relief by the adjustment of vast earth-blocks separated by radial fractures. These movements commenced just prior to the deposition of the lowest beds of the Mawheranui Series. They were again active prior to the periods represented by the Oamaru and Pareora series respectively, and culminated in the great movements that brought the Tertiary to a close. It may be safely stated that the highlands of New Zealand are all to be ascribed to these Tertiary stresses, the accumulations ejected by volcanoes being but another expression of the earth-forces that uplifted the great ranges of the North and South Islands. Prior to the deposition of the sediments known as the Mawheranui Series a long period of subaerial denudation had reduced the land to a surface of low relief. Until the close of the Tertiary the land areas of the West Coast do not appear to have attained great altitudes, and during the lengthy periods of stillstand or slow depression intervening between the movements of elevation the areas above the sea were probably still more nearly reduced to base-level. In the case of the earth-blocks that constitute the Alpine chain it is probable that during the main period of denudation (that bridging the gap between the Cretaceous and the Eocene) they, in common with the West Coast land-surface, were reduced to a peneplain. The crustal stresses that caused the Tertiary deformations, and produced in the West Coast proper a series of block-mountains separated by rift-valleys and not differing materially in elevation among themselves, also brought about a general uplift of the central mountain region of the South Island, as well as a marked differential elevation of the blocks of which it is composed. Of these the lowest are decidedly above the level of the highest of the West Coast area. This difference in height undoubtedly prevailed after the movement that brought the Oamaru period to a close, and probably was more or less marked throughout the whole Tertiary epoch.

A study of the fault-maps issued with No. 17 and this bulletin shows that a great number of the major fractures strike north-east—that is, parallel with the Alps; and there

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* See p. 70.

† Park, J.: "On the Geology of the Owen and Wangapeka Goldfields." Rep. Geol. Explor. during 1887–88, No. 19, 1888, p. 76.

‡ McKay, A.: "The Baton River and Wangapeka Districts and Mount Arthur Range." Rep. Geol. Explor. during 1878–79, No. 12, 1879, pp. 125, 127.

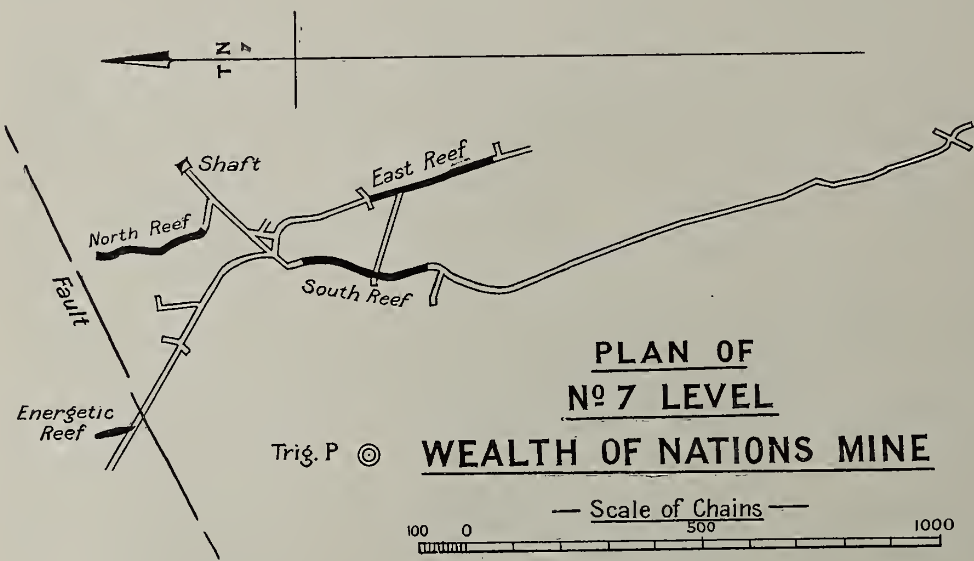
§ McKay, A.: *Loc. cit.*, p. 128. N.Z. G.S. Bull. No. 3 (New Series), 1907, pp. 34, 35.

|| See p. 70; and N.Z. G.S. Bull. No. 13 (New Series), 1911, p. 50.

¶ N.Z. G.S. Bull. No. 17 (New Series), 1915, p. 69.

** N.Z. G.S. Bull. No. 6 (New Series), 1908, p. 36.

is no doubt but that the force that crumpled the rocks of that range produced lines of weakness in the foreland, against which the folding took place. There are also several prominent fracture-zones of which the orientation approaches magnetic north and south, corresponding to the direction of a folding in the Palæozoic rocks considered to antedate the formation of the Alps. These are parallel with the general trend of the Reefton lode-zones, which probably originated just prior to and were active during the cooling of the magma injected as a result of the orogenic movements that produced the Alpine chain. They are also parallel with the western edge of the Aldrich Deep, a most important element in the physiography of the floor of the Pacific Ocean. A few other fractures strike a little west of north. This is even more notably the case with respect to the Glasgow-Brunner-Victoria highlands, which, though traversed by numerous north-east-striking fractures, have a western margin with a strike slightly west of north. This is in agreement with the trend of the Hauraki Peninsula, a horst with a similar structure and of undoubted Tertiary age. Other well-known physiographic and structural features have a similar orientation, and it is suggested that during Late Tertiary times the crustal stresses accumulated in the New Zealand area were relieved along lines running a little west of north. Throughout the Dominion these deformative movements have been of the plateau-forming type, and have produced elongated, elevated, and depressed areas which are possibly the expression, in the zone of fracture, of forces that, in the zone of flow, produce great folds.



PLAN OF
Nº 7 LEVEL
WEALTH OF NATIONS MINE

CHAPTER VI.

ECONOMIC GEOLOGY.

METALLIFEROUS LODES.

Introduction.

From an economic standpoint the Reefton Subdivision is chiefly interesting owing to its deposits of gold and coal. The former consist of quartz veins, and of gravel and conglomerates containing detrital gold. The quartz veins, in addition to gold, carry the commercially valuable sulphides, stibnite and arsenopyrite; while chalcopyrite (copper-pyrites) occurs sparingly in several mines, and bismuthinite has been reported from one. Other lodes which have so far received little or no attention carry molybdenum and copper as their most valuable constituents, with a little silver and less gold. A veinlet of galena not especially argentiferous was discovered many years ago, but is of no commercial value, and lead in small amount is known to be associated with antimonial ores. By far the greater number of the lodes of the subdivision belong to the gold-bearing series, and most of these contain so little of the precious metal that for commercial purposes they may be considered barren.

The auriferous lodes occur in two main areas, of which the more important—the Reefton area—is a strip of Palæozoic sediments lying along the eastern edge of the Grey-Inangahua rift-valley, and stretching from the Big Grey to north of Larry Creek, a distance of twenty-four miles. The width of the belt over which the lodes occur is rarely more than two miles, and is generally much less. The other main block of lode-bearing country is on the western side of the Grey valley, and forms the core of the southern end of the Paparoa Range. It may be conveniently termed the Paparoa area, and in it occur, besides the auriferous lodes, veins containing copper and molybdenum.

By far the greater number of the quartz lodes, and the whole of those of economic importance, are contained in the Palæozoic greywackes and argillites. Veins of quartz are common in the plutonic rocks, and more particularly in the gneisses, a condition which obtains throughout the West Coast; while sometimes also fractured zones of granite are rich in impregnated sulphides. The writer, although he noted several of these occurrences—for example, in Fletcher,* Dilemma,† and Bateman* creeks, also in a small branch of Tobin Stream‡—did not examine any of them carefully. Quite recently, in the granite on the western flank of the mountains north of the Karamea River, a similar zone, which carries gold in addition to iron and arsenical pyrites, has been discovered by Mr. W. G. Jacobsen. The alluvial deposits of Fenian Creek, a branch of the Oparara, that have been worked for many years, probably derived their gold from this mineralized zone, which lies close to the edge of the granite boss. As the occurrences in the Reefton Subdivision differ from this in that they neither are connected with known alluvial deposits nor contain arsenopyrite, it is probable that the dissimilarity extends also to their gold-content.

Definitions of Mining Terms, Etc.

The miners of the Reefton district use certain terms in a sense differing from that in which they are generally employed, although the usage followed nearly always conforms with that obtaining in Australia. One very common term is "mullock," which designates rock as distinct from quartz, whether the latter be payable or not. Rarely the meaning is restricted to the crushed country near a lode, which, however, is usually known as "good-looking" or "kindly" country. Another Australian term in very common use is "reef," used to designate a tabular body of quartz contained in a fissure. When the quartz feathers out the space between the fissure-walls is

* See map of Reefton Survey District. † See map of Brighton Survey District. ‡ See map of Waitahu Survey District.

generally occupied by crushed rock, known as "reef formation" or "reef-track." This "track" often leads to another quartz body, the whole constituting what is usually defined as a "lode." Frequently a small quartz vein persists in the gouge of the "reef formation," forming a "leader" or "stringer," the latter term being preferred for the larger and more persistent occurrences. Often many leaders traverse the crushed rock within the fissure, and sometimes these are rich enough in gold to permit of the whole being extracted as ore. Such a composite lode receives the name of "mullock reef." The strike of an ore-body is termed its "course," and the former term is used wrongly in lieu of "pitch" or "rake" to designate the endlong dip in strike of the deposit. The well-known and necessary term "shoot" or "ore-shoot" is never employed, its place being filled by "block." Since the ore-shoots of this region frequently consist of a succession of quartz lenses, or have been broken up by faults, this term may conveniently be retained to designate an individual lens or a fault-displaced fragment of an ore-shoot, meanings already possessed by the word. As in other mining districts, several ore-shoots may be developed along one fissure, and the occurrence is then designated a "reef-line," or briefly a "line,"* the term being then equivalent to lode. A wider meaning, however, is often intended. Thus later movements may have cut and distorted the ore-bearing fissure, or the original disrupting stress may have found relief in a number of parallel fissures, disconnected and not in exact alignment. Such a lode-series is also called a "line." When a number of lode-series or "lines" are distributed over a considerable area with sub-parallel strike a lode-system results. In the Reefton region a number of these systems exist, which, though differing in orientation, closely follow one another in longitudinal extension, and are evidently all of common origin. The whole forms a run of lodes or a mineralized belt.

Lode-fissures.

As already stated, all the valuable ore-deposits of the subdivision are related to fissures occurring in the Palæozoic rocks. The very fact of their containing ore is strong presumptive evidence that the fracturing is in the nature of normal faulting, and not of overthrusting, a phenomenon that seems to be followed by ore-formation only with extreme rarity.† This assumption is strongly supported by the steepness of the dips of the fractures. It may be mentioned that no proof of this statement can be adduced, for not only are the enclosing rocks of great uniformity, but the lodes nearly always appear to follow the bedding. This latter structure, however, is more apparent than real, being caused by the sheeting of the country, owing to the intensity of the deformative movements, and in some cases at least it can be shown that the lodes cross the bedding of the country at small angles.

The lode-fissures of the subdivision fall naturally in two groups, according to their areal distribution. The general features of the distribution of the fissures of each area have been described in an earlier chapter, and it is proposed in this place only to put the facts there stated into tabular form in so far as they apply to the Reefton area. The lodes here occur in three runs, of which the two western are so closely related genetically that they may conveniently be considered together. It is in connection with these latter that, with few exceptions, the mines of the subdivision are placed. The data in respect to the lodes of the Paparoa area are too inexact to permit of such a tabulation, and for the information available the reader is referred to page 58 *et seq.*

* In the "sixties" the alluvial digger was required by law to mark out by means of flags the lead of gold worked, or the supposed position of the lead. This custom was followed when the auriferous quartz veins were discovered, and the courses of the lodes were marked out by a line of flags. The writer understands that similar usages prevailed in Victoria, where the term "line" has a like meaning.

† Beyschlag, Vogt, and Krusch: "Ore Deposits." Translated by S. J. Truscott. Vol. i, 1914, p. 62.

Classification of the Auriferous Lodes of the Reefton Area.

System.	Group.	Lode-series.	Lode.
Larry	Caledonian	Potter's	Caledonian.
			No. 2 South Larry's.
	Italian Gully	Walker's	Golden Arch.
			Garibaldi.
Waitahu	Capleston	Topfer's	Welcome-Hopeful.
			Fiery Cross.
			Just-in-Time.
			Lone Star.
		Gaffney's	Specimen Hill.
			Pactolus.
			Lady of the Lake.
	Painkiller	Western	Gladstone.
			Sir Charles Russell.
			Ulster.
		Eastern	Colorado.
	Ajax	Kelly's	Inglewood-Victoria.
			Comstock - Golden Treasure.
			Band of Hope.
			Perseverance.
		Walshe's	Golden Fleece.
			Ajax.
			Royal.
			Venus.
		Anderson's ..	Anderson's.
			Invincible.
Inangahua	Crushington	Smith's	Energetic.
			Wealth of Nations.
			Keep-it-Dark (east).
			Hercules.
			Pandora.
		Western	Eclipse.
			Heather Bell.
			Keep-it-Dark (west)
	Auld Creek	Ranft's	Fraternal.
			Bonanza.
	Globe-Progress ..	..	Globe-Progress.
	Merrijigs	Adams'	Union.
			General Gordon.
			Empress.
			Souvenir.
			Big Blow.
			Supreme.
			Lady Louisa.
			Inkerman.
		Lees'	Inkerman West.
			Scotia.
			Gallant.
			Sir Francis Drake.
			Happy Valley.
			Exchange.
			Cumberland.
		Western	Hard-to-Find.
Snowy ..	Golden Lead	McGee's	Golden Lead.
			A1.
			Merrijigs.
	Big River	Doogan's	National.
			Big River North.
			Big River.
		Sunderland's ..	Golden Hill.
			St. George.
			Matthias.
	Blackwater	Hurley's	Hurley's Leader.
			Empire. (?)
			Imperial. (?)
		Martin's	Blackwater.
			Blackwater South.
			Snowy River.
	Millerton	Dank's	Lee's.
			Saraty's.
			Millerton.
	Maori Gully	..	Golden Point.
			Morning Star.

Nature of the Fissure-filling.

The gangue of the lodes of the Reefton Subdivision consists almost entirely of quartz with sulphides, and very rarely calcite in subordinate amount. There are two varieties of quartz, one being white, massive, and coarsely crystalline, and the other darker, generally of a bluish tint, and of an oily lustre. Among the metallic minerals which are as a whole characteristic of the latter variety of gangue, pyrite and arsenopyrite are the commonest, while stibnite also frequently occurs. Chalcopyrite has been reported from a few mines (Supreme, Big River, and Blackwater), and invariably also accompanies molybdenite, a mineral occasionally seen. With the former mineral, moreover, silver, probably in combination, is always associated, while the gold in such lodes is present only in the scantiest amount. Galena as a constituent of quartz lodes has been reported from Moonlight and Blackball creeks, and a small vein of this mineral was struck in the Caledonian Mine, while the concentrates from the Inglewood Mine contain up to 1 per cent. of lead.

The distribution of the common sulphides in the quartz gangue is very variable. Their occurrence is never massive, although occasionally stibnite is disseminated through the quartz so abundantly as to give the appearance of this structure. The quantity of stibnite present, however, is rarely more than 20 per cent. of the whole mass, and only by careful hand-picking is it possible to get a product containing even 40 per cent. of metallic antimony. In such occurrences the other common sulphides are absent, and the gold-content low. When the quartz contains a moderate amount of the sulphides (2 to 4 per cent.) their distribution is very irregular, and they do not occupy any definite position, but are found most commonly on the margin of the lodes or next to thin layers of embedded country.

The gold occurs not only free and amenable to amalgamation, but also intimately associated with the sulphides, and requiring some other method of treatment for its recovery. In the white coarsely crystalline quartz it is found in visible specks, while in the bluish oily quartz it is usually disseminated more finely, the richest portions of the ore being generally next the walls or next the thin layers of country contained in the quartz. The gold itself is very pure, generally varying in fineness from 96 to 97 per cent. The gold from the Caledonian Claim, however, contained only 92 per cent. of the pure metal, and that from the Alpine Claim, Lyell, only about 90 per cent., the impurity in both cases being chiefly silver. It should be noted that the lodes of these localities occur in rock more or less altered by thermal metamorphism, and that the gold is developed in relatively very coarse specks, often as large as a pea.

By far the greater number of the quartz lodes contain practically no sulphides, and consist of white, vitreous, coarsely crystalline quartz that under the microscope exhibits a coarse even-grained mosaic of quartz-grains, unshaded, in polarized light, by any strain phenomena. This type of quartz rarely carries gold in readily detectable quantities, and very rarely in workable amount. On the other hand, the opaque bluish quartz with oily lustre always carries sulphides and gold. Under the microscope the quartz-grains of payable ore are seen to be very irregular in size, some portions of a single slice exhibiting a coarse mosaic and others a fine, the line of separation being usually a gliding zone consisting chiefly of finely ground quartz, but also containing crushed country, various sulphides, and gold. Often these latter are entirely absent, the dark colour, opacity, and lustre of the quartz being then possibly due "to the total internal reflection from strain surfaces."* Again, although the number of slides examined was insufficient to permit of a safe generalization, the gas-pores seen in the "kindly"

* Maclaren, J. Malcolm: "Gold," 1908, p. 49. The present writer takes a "strain surface" to mean a gliding plane.

quartz were decidedly more numerous than in the "hungry" variety. It should be noted also that the individual grains exhibit undulose extinction to a marked extent. Evidently during the formation of the mineralized quartz the fissure in which deposition took place was in a constant state of activity. This is further borne out by the numerous layers, usually nothing more than the veriest films, of material from the country which occur in the quartz parallel with the lode-walls. These are evidently due to frequent slight movements causing almost imperceptible reopenings of the fissure; and to this cause must also be ascribed the lamination of the ore. Occasionally recemented brecciated quartz occurs, of which the best example noted by the writer was exhibited by parts of the Pioneer block of the Progress Mine.* Here angular fragments of light-coloured quartz are contained in a minimal amount of dark cement, which is obviously comminuted country, silicified, and in part replaced by quartz. In many of the lodes fragments of the wall-rock are entirely surrounded by quartz, and there is not the slightest doubt but that the quartz itself is in part a replacement of the original pug filling of the fissures. At the Caledonian Mine, indeed, the quartz grades into the slightly altered rock of the country; but in all other cases, although it may be "frozen" to the wall-rock, it is sharply distinguishable from enclosing strata. This distinct demarcation makes it probable that replacement of the country by quartz was not an important method of lode-formation in the Reefton Subdivision. The supposition that slight movements often took place along the fissures adequately accounts for the splitting-up of an ore-lens at its edges and the interlocking of quartz and country there exhibited. It explains the fact that the lodes consist of lenticular masses of quartz, which in any direction may be separated one from another by "track," or may overlap with a thin parting of crushed country between the ends of adjacent lenses. Those in the same shoot may vary greatly in size and tenor, and consist of quartz of different appearance and mineral-content. It also accounts for the so-called "mullock" lodes, which consist of subparallel veinlets of quartz separated by thin layers of sheared country; in these cases the reopening of the fissure took place not exactly along the old fracture, but some distance in the hanging- or foot-wall. As would be expected, there are numerous examples of lodes, of types intermediate between the "mullock" lode and the ordinary quartz lode. It should also be stated that there is every gradation between the lode consisting of white, coarsely crystalline, and rarely laminated quartz and that consisting of the semi-opaque laminated quartz characteristic of the richly auriferous ores of the district. The ores carrying molybdenite and chalcopyrite as their principal mineral constituents approach in appearance rather those of the former than those of the latter variety, as also does the quartz of the Caledonian shoot.

Distribution of the Ore and Minerals in Depth.

In the preceding section an attempt was made to state the pertinent facts known concerning the material filling the fissures in general. Since no other but the auriferous lodes have been explored in depth, it is possible in this section to treat only of them.

In such ore-shoots as have been sufficiently exploited and are not too much faulted to yield reliable information on the point, the pitch of the lode is in every case northward, at angles which vary between 27° and 35° in the Boatman and Caledonian groups, between 50° and 60° in the Crushington and Ajax groups, and is about 38° in the case of the great Blackwater shoot. This constancy of the direction and relative uniformity in the amount of the pitch of the lodes undoubtedly point to an origin common to all cases, and the writer considers it to be due to pre-mineral structural features of the

* Brecciated quartz is also reported from the Big River and Keep-it-Dark mines.

country. Thus the Blackwater lode faults, and is itself more or less dislocated by, a small diabase dyke that cuts the lode on a line nearly parallel with the pitch as determined by the southern edge of the shoot and by the position of its thickest portion.* In the Wealth of Nations Mine two lode-channels occur, separated by about 200 ft. of country, and what is known as the south block lies on the western of these, while the north block is on the eastern. A diagonal fissure connecting the two channels terminates the northern end of the south block and the southern end of the north block. In the Hopeful-Welcome shoot the northern edge in all levels from No. 2 to No. 5 ended in broken faulted country, into which the "track" penetrated with a westerly trend. In 1898 the north block was found lying 200 ft. to the westward of the line of the main shoot, and the "track" connecting the ore-bodies must be considered a pre-mineral fracture. It must also be noted that the ore-shoots invariably terminate in country decidedly more broken and shattered than that forming their normal walls, and in this disturbed country the lode "track" usually changes its direction. The writer considers that the facts are most readily explained by supposing that the fractures now containing the lodes were formed across a series of older fractures, being frequently more or less deflected in the process.† The line of intersection is naturally marked by shattering, and in the mineralized fissure determines the position of the edge of the shoot. In theory the pitch of this intersection in respect to the later fracture will depend upon the strikes and dips of both the older and the mineralized fissures, and will be similar for each particular group of lodes, conditions that actually obtain in the field.

The secondary enrichment of gold-ores through the agency of surface waters does not play an important part in the Reefton district. The oxidized zone rarely extends more than 50 ft. beneath the outcrop, except that in the neighbourhood of powerful faults this depth may be several times exceeded. On the other hand, there are numerous instances where unoxidized ore is found within a few feet of the surface. This low range in the variation in the level of the ground-water is probably to be explained by the heavy and regularly distributed rainfall and by the impermeable nature of the Palæozoic sediments. The gold enrichment in the oxidized zone is not decided, and the upper margin of the sulphide ore is not distinguished by an increase in its content either of gold or of accessory minerals as compared with undoubted primary ore beneath. The concentration of gold in the oxidized zone is due rather to the mechanical action of the water in carrying down gold-particles freed by surface-erosion than to the dissolving-power of the solutions. In the Paparoa group of lodes the ore of the Minerva and Crœsus shoots apparently rapidly decreased in value in depth; but the fact that the workings are inaccessible, the fewness of the data available, and the small amount of exploration undertaken, do not permit of any opinion being formed as to whether these occurrences are examples of secondary enrichment or not.

The only undoubted instance of the alteration of the primary ore in the shoots so far mined is furnished by the distribution of stibnite. In the case of this mineral there is a decided diminution in depth in the Welcome, Golden Fleece, and Globe mines. In some shoots stibnite—which, where it occurs in moderate amount, is considered a good indication for gold—is entirely absent, as at the Caledonian, No. 2 South Larry's, Kirwan's Reward, Minerva, and Crœsus. In others again the mineral occurs very sparingly, as at the Golden Arch, Wealth of Nations, and Blackwater. In the ore-shoots that have been most extensively mined—namely, the Welcome, Golden

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* See section of Blackwater Mine, Map No. 13.

† Evidence of a somewhat similar occurrence appears in the Waihi Grand Junction Mine. N.Z. G.S. 10th Ann. Rep., 1916, p. 10.

Fleece, Wealth of Nations, Keep-it-Dark, Globe, and Big River—it is found that in a general way, and allowing for the influence of faults, no alteration either in the size of the ore-bodies or in the mineral-content, as far as gold, arsenopyrite, and pyrite are concerned, can be detected between the upper and lower levels. This, however, is a question that will be further discussed on a later page.

Alteration of the Wall-rocks.

The wall-rock of the auriferous lodes consists of a relatively soft structureless rock, generally not more than a few feet thick, decidedly lighter in colour than slate or argillite, and containing crystals of pyrite and arsenopyrite, the latter of which, although contained in no greater quantity, are much the larger and more prominent. Under the microscope this rock is seen to consist largely of quartz, sericite, and a little carbonate, presumably calcite. Unaltered greywacke consists chiefly of quartz, feldspar, and chlorite. Of these minerals the feldspar and chlorite, and probably also the quartz in part, are replaced by sericite, an alteration requiring the addition of potash. Sometimes the lodes are contained in or cross diabase dykes, the minerals of which are also greatly altered. Referring to this alteration, Finlayson writes: "In the first stage the feldspars become more and more replaced by carbonates [and micaceous material] till the twinning is indistinguishable, and they practically consist of sericite-calcite pseudomorphs. Olivine is replaced by chlorite and serpentine, augite by magnetite (or ilmenite) and a leek-green serpentine. The ophitic structure can, however, still be traced. With further alteration all structure is lost, even the outlines of crystals being obliterated. The rock becomes an aggregate of carbonates and sericite with a good deal of opaque iron oxide and a little quartz, probably introduced. Strings and patches of pale-green chlorite are present at first, but these are eventually altered to sericitic matter. Pyrite crystals are also frequently present."* Small masses of siderite occur in connection with the diabase dyke in the Blackwater Mine, and this mineral is undoubtedly present in considerable amount in diabase altered by lode-forming solutions.

Chemically the sedimentary rocks are not greatly altered from the original greywacke and argillite, the main change being an increase in the potash-content, as the following analyses† show:—

	Unaltered Greywacke. Boatman Creek.	Altered Greywacke Blackwater Mine.	Unaltered Argillite. Boatman Creek.	Altered Argillite. Garden Gully.
SiO_2	74·91	67·90	53·59	51·43
Al_2O_3	10·16	14·62	21·95	20·37
K_2O	2·24	4·07	5·64	6·40

These facts clearly show that the auriferous ores of the Reefton Subdivision have been deposited by solutions that have produced metasomatism, of the type called by Lindgren‡ the sericitic calcitic type.

Don§ has assayed samples of wall-rock at various distances from the lodes from the Wealth of Nations and Progress mines, and has found that these are notably auriferous only when they contain sulphides.

* Finlayson, A. M.: "The Geology of the Reefton Gold-veins." Trans., vol. xli, 1909, p. 88.

† For the complete analyses of these rocks see p. 71.

‡ Lindgren, W.: "Metasomatic Processes in Fissure Veins." Trans. Amer. Inst. Min. Eng., vol. xxx, 1901, pp. 664 *et seq.*

§ Don, J. R.: "The Genesis of certain Auriferous Lodes." Trans. Amer. Inst. Min. Eng., vol. xxvii, 1898, p. 645.

Genesis of the Quartz Lodes.

There are two theories accounting for the formation of quartz lodes, one of which considers them as deposited from meteoric waters, while the other derives them from magmatic sources. The writer believes that by far the greater number of the quartz lodes of the Reefton Subdivision must be ascribed to the latter mode of origin, and would place in the former only the siliceous veinlets that are frequently developed in the cracks and joint-planes of greywacke and some of the inconsiderable stringers found in fault-planes, within a few hundred feet of the surface.

Several of the auriferous lodes have been traced to a depth of 1,500 ft. from the surface, and one to more than 2,000 ft., without displaying any notable variation in size and mineral-content. All these lodes are many hundreds of feet below the present ground-water level, and two of them are well below sea-level. The workings become dry and dusty at moderate depth, and it seems inconceivable that the extremely limited underground circulation, which from the very nature of the country could never have been much greater than at present, has been able to produce the lodes.

This problem, however, is best approached from the point of origin of the quartz. Within the basin of Larry River the intricate surface of contact between the Aorere rocks and the granite intruding them is exposed by the stream-channels in several places. At two points large quartz-masses containing occasional plates of muscovite, and apparently grading into the igneous rock, separate it from the sedimentary strata. A large lode, at least 12 ft. in thickness, composed of similar quartz, and containing grains of pyrite and chalcopyrite in addition to muscovite, occurs within a chain of one of these tongues of quartz-enveloped granite (*i.e.*, that outcropping farthest down Bateman Creek, the south branch of the Larry River). A sample from this lode was found to contain 2 gr. of gold and 5 dwt. of silver per ton, and 0·05 per cent. of copper. A few chains above the lower forks of Larry River a great face of somewhat shattered and altered greywacke showing at one point a small granite tongue, presumably connected with the main mass across the river, occurs; and among the débris from this face a small angular fragment of richly auriferous quartz, with country attached, was found. Several quartz stringers were observed to traverse this face, and, although none showed gold, there is not the slightest doubt but that the specimen found was derived from one of these or from some similar vein.

In the basin of New Creek near Lyell (see Bulletin No. 17, page 198, and map) a non-auriferous 20 ft. quartz lode containing muscovite and pyrite, and developed along one side of a granite dyke, has been explored by driving. Near at hand, in Tichborne Creek, a small tributary of New Creek, a lode 10 ft. thick, undoubtedly a continuation of that above mentioned, and also containing muscovite and pyrite, the former mineral being very plentiful, especially within a few inches of its edge, occurs. A few chains farther up the stream a lode, 2 ft. wide, was worked by the Sir Charles Napier Company for an unsatisfactory yield of gold. The sedimentary rock next all these lodes consists of bands of schistose quartz-mica hornfels, some of the layers of which contain knots of cordierite.

Again, on the coast-line about 25 chains south of the Seventeen-mile Bluff two dykes of fine-grained aplite, containing pyrite, cut the greywacke on the beach. The strike of these dykes would carry them directly to a quartz lode, containing muscovite, pyrite, and molybdenite, that outcrops in the bed of the rill entering the sea near this point. This lode can be traced about 5 chains, is not more than 15 chains from the dykes, and has a similar strike. The intervening space is covered by a shingle-fan ; but it is a fair inference that the lode is, if not a direct continuation of the dykes, closely connected with them.

Thus there is evidence, strong but not absolute, that quartz lodes containing chalcopyrite or molybdenite, and carrying gold in small quantity, are closely associated with the igneous intrusions. It should be noted also that the few lodes within the subdivision carrying these minerals occur in greywacke, either very close to granite or altered by thermal metamorphism. Thus the double vein outcropping in McConnochie Creek, a branch of the Inangahua draining from Mount Albert, and containing 17 dwt. of silver per ton, 1·65 per cent. of copper, and under 0·05 per cent. of molybdenum, is less than 10 chains from a granite-outcrop ; while the country of the Paparoa area, where all the other quartz lodes carrying molybdenum and copper are situated, has also been affected by thermal metamorphism. These latter lodes carry gold and silver ; one from the upper valley of Moonlight Creek, in which a flake of molybdenite was seen, contained 15 gr. of gold and 8 dwt. 19 gr. of silver per ton, and 3·20 per cent. of copper. Closely associated with it are other lodes carrying gold, arsenopyrite, pyrite, and occasionally stibnite ; while some claims in the area, such as the Taffy, Crœsus, and Minerva, contain lodes commercially valuable for their gold-content, and of these the second and third also carry copper in small amount.

Another link in the chain connecting the normal gold-bearing lodes with the pegmatitic granite dykes is furnished by the veins of the Caledonian group. The auriferous ore of this locality penetrates into and is more or less intimately mixed with the country, much of which was mined and treated at the battery. A similar penetration of hornfels by pegmatitic dykes was frequently noted.

The writer believes that the natural processes that culminated in the formation of the quartz lodes began during the differentiation of the igne us magmas, from which at least some of the granite batholiths of the subdivision have been derived. As the magma cooled, one may suppose that the portion still liquid, rich in silica, soluble carbonates, and carbon dioxide, was injected into fissures formed by the shrinkage of the whole. Gradually the " mother liquor " became richer in water, more fluid, and able to penetrate farther and farther into the constantly extending fractures of the crust, which consisted in part of sedimentary rocks and in part of a consolidated shell of igneous rock. The solutions as they rose to the surface along the fissures were subjected to decreasing pressure and temperature, and conditions favourable to the deposition of their mineral-content arose. The varying properties of the minerals determined their formation at different depths, and thus zones characterized by a particular mineral or association of minerals tended to be developed. The continual shrinkage of the magma produced crustal stresses, and caused the old fissures to reopen or new ones to form ; and as in time the composition of the solutions and perhaps the rock-temperature altered, different bands of the same lode, or different lodes in the same locality, do not have the same composition. The active agents in maintaining the sulphides in solution were the alkaline carbonates and heat, and these might decrease in amount either through exhaustion of supply from the central source or from dissipation into the wall-rocks. By either means the rising water finally contained mainly silica, deposited only quartz, and did not alter the wall-rocks. Thus barren veins are considered to be due to depletion of certain constituents, either of the intrusive mass or of solutions from it. Of the latter type of vein all trace has been long since removed by denudation, and the barren lodes remaining may logically be considered the product of a magma depleted of its alkaline carbonates and sulphides. The relative abundance of barren quartz veins seems to indicate that the period during which commercially valuable lodes were deposited represents but a brief interval in the history of hydrothermal after-action.

Lindgren* has tentatively formulated lists of minerals characteristic of different zones of deposition, and has also prepared a list of those persistent through many zones. Now, the deposition of any mineral depends upon the chemical composition of the solution as well as upon physical conditions, and as both are subject to variation the difficulties attending the devising of such a scheme are very great. This is apparent enough even when one metalliferous province is considered, and increases enormously when many are included. Denudation has exposed the lodes of the West Coast province to various depths, and the following table has been prepared to show what is known of the various ore-deposition zones of this region:—

—	Zone characterized by				Examples.
	Sulphides.	Gangue Mineral.	Wall-rock Alteration.	Ratio of Gold to Silver.	
1	Chalcopyrite, pyrite, molybdenite	Quartz, muscovite, feldspar	Very slight ..	1 to 100–300	Mount Radiant lodes. (Bull. No. 11, 1910, p. 24 *et seq.*
2	Pyrite, chalcopyrite, molybdenite	Quartz, muscovite	Very slight ..	1 to 10–50..	Moonlight (p. 122); Bateman Creek (p. 121); lodes of so-called "Kanieri Series" (Bull. No. 1, 1906, p. 58).
3	Pyrite, chalcopyrite, pyrrhotite	Quartz ..	Replacement and silicification	3 to 2 ..	Poerua (N.Z. G.S. 7th Ann. Rep., 1913, p. 128).
4	Pyrite, arsenopyrite, chalcopyrite (rare)	Quartz ..	Replacement, silicification, and slight sericitization	5–10 to 1 ..	Lyell. Wilberforce (Bull. No. 1, 1906, p. 51); Caledonian (p. 117).
5	Pyrite, arsenopyrite, stibnite (not common), chalcopyrite (very rare)	Quartz, siderite (very rare)	Sericitization ..	25 to 1 ..	Deeper part of Reefton lodes, also outcrops of Blackwater and Golden Arch.
6	Pyrite, arsenopyrite, stibnite, chalcopyrite (very rare)	Quartz ..	Sericitization ..	25 to 1 ..	Upper part of Reefton lodes, unless excepted as above; Langdon's (Bull. No. 13, 1911, p. 84).
7	Pyrite (rare) ..	Quartz ..	Slight sericitization	Barren ..	..

The lodes of Mount Rangitoto,† near Ross, contain galena in addition to chalcopyrite and pyrite, and probably fall between the second and third divisions of the above table.

Persistence of Ore in Depth.

If the theory of ore-formation outlined in the foregoing section be in the main correct it must follow that the quartz veins of the Reefton Subdivision will be found only in the shallow outer zone of the earth's crust. There is, however, nothing in this general statement to imply that the lodes will not extend to a much greater depth than it is possible to follow them by any method of mining now employed. Rickard‡ recently has sought to show that all lodes, including those of the persistent type occurring in the Reefton area, decrease in size and value as they are followed downward, and finally become unprofitable. Typical examples are discussed, and Rickard, in the writer's opinion, establishes his main thesis.

In the Reefton Subdivision experience has shown that the amount of ore commanded by successive levels may vary within wide limits. Some mines, after working an ore-shoot with success for years, have been abandoned because the ore "petered out"

* Lindgren, W.: "The Relation of Ore-deposition to Physical Conditions." *Economic Geology*, vol. ii, 1907, pp. 105–27.
† N.Z. G.S. Bull. No. 6, 1906, p. 146.
‡ Rickard, T. A.: "Persistence of Ore in Depth." Trans. Inst. Mining and Metal., vol. xxiv, 1915, pp. 1–190. Also Jour. Chem. Metal. Min. Soc. of S. Africa, vol. xv. 1915, No. 6, pp. 109–32.

below, and was not found again by any work undertaken: such are the Caledonian, Welcome, Just-in-Time, Golden Treasure, Venus, Anderson's, Energetic, Keep-it-Dark (east shoot), Inkerman (two shoots), and Cumberland. In other cases a continuation of the shoots has been found at greater depth, after passing through a zone wholly or relatively unproductive. Excellent examples of such blanks occur in the Wealth of Nations Mine, where there is a break of over 500 ft.; in the Big River Mine, between No. 6 and No. 7 levels; and in the Progress Mine, where for several years No. 10 level was considered almost a blank. Again, examples have occurred where a level has yielded far more ore than was originally expected: such are No. 9 level of the Progress, the shaft levels of the Murray Creek Mines, and the levels below No. 7 of the Big River.

The writer does not consider that any of the above instances of variation in size of shoots is due to the influence of depth on ore-deposition. In every case these effects are to be attributed to faulting. In the Big River Mine the increase in the amount of ore in the blocks from No. 7 downward is due only indirectly to earth-movements, which have probably caused the non-discovery between No. 2 and No. 6 levels of a southern shoot, the finding of which on the surface led to the original staking-out of the claim. In the Phœnix-Inglewood-Victoria (or Murray Creek) Mine it is reasonable to suppose that the large shoot exposed in the lower levels was broken by faulting into the three apparently independent shoots worked from adits. A somewhat similar instance of blocks, separate on the surface, uniting in depth is afforded by the Globe quartz vein. In cases where the augmentation of the ore is temporary—confined, in fact, to one level, as in No. 6 Keep-it-Dark (west shoot) and No. 9 Globe-Progress Mine—the improvement has probably been brought about by the overlapping, through faulting, of portions of an ore-shoot originally deposited at different depths. In the converse cases where blanks occur, as in the Wealth of Nations and Big River mines, the separation of valuable portions of the shoots was indubitably due to the same primary cause. In the commonest case, that in which the shoots have terminated and have not been rediscovered, earth-movements have undoubtedly produced displacements. In some cases—as in the Caledonian, Welcome, Golden Fleece, Keep-it-Dark (east shoot), Progress (Progress section), and Inkerman (west shoot) mines—the ore-shoots have decreased in size in several successive levels. In others the termination has been abrupt, the line of intersection of the lode and fault-fissures being but slightly inclined from the horizontal: examples have occurred in the Fiery Cross (Just-in-Time shoot), Golden Treasure, Anderson's, Progress (Globe section), Inkerman (east shoot), and Cumberland mines. Shoots naturally show frequent minor changes; but without the intervention of faulting there is no undoubted example of definite or progressive variation of size, and in the reasonably well-explored mines the occurrences above mentioned include all the known decided variations.

In regard to the amount of gold contained in the quartz there does not appear to be either a decided increase or decrease with depth in any of the shoots, in so far as these have been explored. The extraction of the gold contained in the ore is much more complete now than was the case in the early days, owing to the universal use of concentrating machinery and the cyanide process, but it may be assumed that the proportion of the gold in the unoxidized ore recovered by amalgamation has remained fairly constant. It follows, therefore, that there was a tendency for only the richer portions of a shoot to be worked in the early days. A table has been prepared showing the average yield per ton of gold won by amalgamation, during successive periods of years, from the more extensively mined ore-shoots. Though the yields from individual levels are not usually obtainable, nevertheless the table, with one partial exception, shows the average yield from successive horizons in the shoots.

Table of Yields per Ton from various Lodes during Different Periods.

Mine.	Period.	Ounces per Ton.	Mine.	Period.	Ounces per Ton.
Welcome	1876–79	2·116	Keep-it-Dark (west) ..	1899–02	0·246
	1880–83	2·384		1903–06	0·274
	1884–87	1·676		1907–10	0·189
	1888–92	1·744		1911–14	0·222
Fiery Cross	1874–77	1·277	Globe-Progress ..	1884–87	0·372
	1878–82	0·975		1888–91	0·543
	1884–88	1·233		1892–95	0·466
Just-in-Time ..	1875–78	1·649		1896–99	0·444
	1879–83	1·013		1900–02	0·377
	1884–88	1·016		1903–06	0·337
	1889–92	0·994		1907–10	0·280
Ajax-Royal	1872–76	1·000		1911–14	0·210
	1900–03	0·466	Big River	1888–91	0·931
	1904–08	0·393		1892–95	1·697
	1909–11	0·937		1896–99	1·214
Wealth of Nations ..	1873–76	0·691		1900–02	1·125
	1877–81	0·583	..	1903–06	0·974
	1891–94	0·349		1907–10	1·236
	1895–98	0·297		1911–14	1·046
	1899–02	0·375	Blackwater	1908–12	0·501
	1903–06	0·300		1913–15	0·423
	1907–10	0·331	Alpine	1873–74	1·526
	1911–14	0·317		1881–84	0·579
Keep-it-Dark (east) ..	1876–79	0·474		1887–88	0·624
	1881–84	0·654		1891–94	0 620
	1885–88	0·517		1895–97	0·407
	1889–92	0·470		1898–99	0·328
	1893–96	0·468		1900–02	0·233
	1897–98	0·569		*1903–06	0·544

* The tonnage treated during this period was very small, while the gold extracted by cyanidation is also included in the yield.

In the case of the Welcome the first two quadrennial periods refer to yields obtained from ore above No. 6 level, the second two are from ore below No. 6 level. In this adit the subsidiary fractures of the main fault that finally terminated the shoot in No. 9 level had already appeared, and below No. 6 the quartz blocks were so broken that it was no longer possible to avoid the admixture of large quantities of worthless country in the ore sent to the mill. Hence the decrease in the value of the quartz won from the lower levels.

In the Ajax-Royal shoots only one early quadrennial period is shown. In 1877 the Ajax combined with the Golden Fleece Company, and the returns from the richer Golden Fleece shoot caused the yield obtained by the new company to be decidedly higher per ton. This valuable shoot was displaced by faulting in No. 5 level, and has not since been recovered. During the present century the Consolidated Goldfields developed the Ajax and Royal shoots, and the mill they erected was more than capable of dealing with the current product of the mine. Hence one incentive to keep the ore clean was lacking, a condition especially manifest during the 1904–8 quinquennium, when the vein-quartz above the main adit had been exhausted, and it became increasingly difficult to keep the mill supplied from ore-bodies more distant from the shaft at each short-lived level. The tributers who extracted the ore from

No. 15 level were not concerned whether the battery ran continuously or not, and the ore won was clean, and approached in value per ton that from the upper horizons of the shoots.

In the Wealth of Nations Mine the ten-year gap between the two earliest and the later periods represents in time the 500 ft. vertical displacement between the ore-bodies worked from adits and those worked from the shafts. Traces of ore were followed down the fault-zone; but the marked difference in value between the upper and lower portions of the shoots, of which three are worked in the lower portion of the mine, suggests either that a shoot or shoots have not yet been found below or, more probably, that one of the large and poorer shoots is unknown near the surface. It should be noted that all the blocks worked from the adits were in country more or less disturbed, and occurred in unlike attitudes.

In regard to the variation in yield shown by the Keep-it-Dark (west shoot) in the two middle periods, it should be noted that during the first of these the "eyes of the mine were picked" to provide dividends, and that the impoverishment shown during the second of these time-intervals indicates the crushing of the lower-grade ore-bodies, in great part developed, but not extracted, between 1903 and 1906. The mean of these two periods should therefore be taken.

To a greater degree even than in the Keep-it-Dark (west shoot), large masses of low-grade ore exist in each level of the Globe-Progress Mine, and when developmental work did not disclose more profitable ore this was attacked. Until 1898, when the property was acquired by the Progress Mines, the vein was worked by the Globe, Oriental, and Progress companies, and these did not operate so systematically or so cheaply as their large successor. Consequently only the richer portions of the vein were extracted during the first four periods. When the Progress Mines took possession six levels were in existence, and by 1902 four more had been opened. Thus before the end of the first of the later group of quadrennial periods all the levels save one had already been opened, and for many years ore was drawn from all levels from No. 2 downward, while as late as 1914 ore was stoped from No. 5 level. The mill has not crushed to its full capacity since 1907, and for several years before the supply of ore had not been abundant. Thus from 1888 to 1899 the diminishing returns from the Globe-Progress may reasonably be ascribed to the fact that it was approximately as profitable to extract ore already developed as to open up and stope blocks of slightly higher tenor. From 1900 to 1914 the decrease in the yield per ton is due to the gradual exhaustion of the more valuable portions of ore-bodies, the limits of which had been roughly determined quite early in that period.

In the case of the Blackwater shoot, though No. 7 level is now more than 1,000 ft. below the surface, the ore each year has been extracted from several levels, so that there are as yet insufficient data for the purposes of the present inquiry. The shoot has been included in the table merely to show the effect of a change in the method of working on the tenor of the ore supplied to the mill. Until the middle of 1912 the ore was stoped by day labour, but from 1913 onward the contract system has been in vogue. The vein is small, averaging under 2 ft.; the contractors are paid by weight, and, in spite of all precautions, more worthless mullock finds its way to the battery as ore than was formerly the case.

The writer has endeavoured to show that the yields from the Hopeful-Welcome and Globe-Progress shoots do not necessarily indicate a decrease with depth of the amount of gold contained in the ore. The records of the other shoots perhaps on the whole show a very slight diminution in the amount of gold won by amalgamation per ton of ore milled. This, however, does not imply an actual impoverishment with depth, because, as already pointed out, the method of treatment is decidedly different from that of the early days. At that time the necessity of fixing the gold as early in the treatment as possible was obvious, but now gold escaping amalgamation may still be caught on the concentrating-machines or dissolved in the cyanide-vats. The tendency at the present time is not to add mercury to the mortars, but to rely entirely on the copper tables for amalgamation. On the other hand, frequently renewed wire-woven screens are now used instead of punched plates, and consequently the pulp is decidedly more uniform than formerly, and it is generally acknowledged that the methods of amalgamation employed are quite as efficient as those used in the early days. Again, in stoping, machine drills are coming more and more into use ; deeper holes are bored ; and with the consequent heavier charges of explosives there is more likelihood, especially when the lode is narrow, of more country being mixed with the broken quartz. Moreover, there is a tendency to extract the ore more thoroughly from the fissures, and this implies the stoping of smaller widths and a correspondingly greater admixture of "mullock." Sometimes, even in mines where development is well forward, occasions arise when the mill is short of ore, and the miner to make good the deficiency breaks lode-matter known to be barely profitable. This was more unlikely to happen formerly than nowadays, when the advantages of continuous crushing by the battery tend to be much overrated. Again, it is known that the tonnage crushed has not been always reported accurately, while in other cases, especially in the early days, the yield has been given in ounces of retorted and not melted gold. The above considerations are sufficient to show that a slight change in the amount of gold saved by amalgamation over a wide period of years cannot be considered proof of variation in the composition of the ore in depth.

In the neighbourhood of Reefton the ore-shoots that have been mined to considerable depths have all been contained in country that shows not the slightest trace of thermal metamorphism. Nevertheless, some ore-bodies of considerable richness, and undoubtedly closely connected with the lodes of the Reefton neighbourhood, have been worked in rock slightly metamorphosed by granite. Such ore-bodies were found in the Caledonian Mine, in No. 2 South Larry's, in Kirwan's Reward, in the mines of the Paparoa area, and in those in the vicinity of Lyell and New creeks. The extraction of ore in all of these has, for one reason or another, now ceased. The Caledonian shoot was cut off by a fault at a depth of less than 200 ft., and has not since been recovered ; the "mullock reef" worked by the No. 2 South Larry's Company is reported to have merged in depth into a large quartz vein of too low a grade to yield a profit ; the Kirwan's Reward gold was extracted from a mixture of quartz fragments and country formed by the crushing of an ore-body by faulting, and all efforts to trace the downward extension of this ore-body have hitherto failed. In the Paparoa area the Taffy stock-work rests on a flat floor of greywacke—a situation evidently due to earth - movements ; in the Crœsus the ore of a 3 ft. vein was "sweetened" by rich quartz from a hanging-wall leader, and when this latter was lost the mine became unpayable ; in the case of the Minerva Mine the large low-grade quartz-body still persists in the deepest workings, but the reason that caused the suspension of operations could not definitely be ascertained. The writer has no personal knowledge of any of the successful mines in the neighbourhood of Lyell and New creeks. Here most of the claims depended on small but astonishingly rich leaders, none of which could be followed to a considerable depth. It is notorious, however, that the distribution of such leaders is most erratic, that individual leaders are short-lived, and that conditions favourable to their occurrence are far more persistent both in horizontal and vertical extension than any one leader. Thus in No. 7 level of the Alpine Mine at Lyell a phenomenally rich leader was discovered at a depth considerably below that to which any of the leader claims had been explored. The Victory shoot at New Creek was, from the description given the writer, probably cut off by a fault above the lowest adit. The shoots of the Alpine Claim were worked continuously from 1872 till 1906, and this mine was the only one in the Lyell district to attain a considerable depth. Of the earlier half of the period of active operation the annual yields are only in part available, so that the figures for this mine given in the table on page 125 are by no means complete. They prove, however, an undoubted and progressive impoverishment in depth of the ore-bodies of the Alpine Mine. Down to No. 11 level, 1,250 ft. below the outcrop, the lode, although of diminishing value, maintained its size. In No. 12 level, however, the blocks were small and broken, and the Inspector of Mines reports that earth-movements, evidently of considerable magnitude, had taken place at this horizon. The quartz here was, on the whole, of very low grade, and no attempt has yet been made to discover the downward extension of the lode.

The facts of observation in respect to ore-impoverishment with depth in the Reefton district are as follow: (1) In the ore-shoots penetrating the unaltered sediments there is no evidence of impoverishment in depth; (2) numerous ore-bodies have been extracted from the metamorphosed rocks surrounding the granites. The only one of these followed to a considerable depth showed pronounced impoverishment. There are some doubtful instances of diminished value, while the remainder, owing to mechanical displacements, could not be followed far below the surface.

The genesis of the lodes has already been discussed. Briefly, they are considered to have been deposited in fracture-planes by hot solutions escaping from a cooling magma. From the fact that ore, which may in this case be defined as quartz sufficiently auriferous to be attractive to the miner, occurs in less than 1 per cent. of the veins, it seems probable that these solutions were capable of forming ore-bodies during a very brief portion of the period of pneumatolytic after-action. Seeing that gas-pores are decidedly more numerous in ore than in barren quartz, and that the country of rich lodes is more altered than that of worthless ones, it is considered that the former were deposited by the solutions first escaping. As the amount of gold and sulphides in these decreased, so would decrease the value of the quartz formed from them. Since rich ore occurs between walls of greywacke, argillite, and diabase, and since the same shoot may traverse all three without variation, it is believed that the principal factors controlling the deposition of gold were decreasing temperature and pressure. The former is by far the more potent,* and in a general discussion the effects of diminishing pressure may be ignored. In the neighbourhood of an unconsolidated magma the isothermal or equal-temperature shells must be chiefly determined not by depth below the surface, but by the position of the contact between the intrusive rock and that intruded. The nature of the ore shows that the solutions from which it was deposited escaped through narrow fissures, and the effect of such slender streams on the position of the isothermal surfaces must have been quite inconsiderable. As the solutions rose, a rock-temperature must have been reached at which ore began to be deposited. It is assumed that the solutions issuing from different portions of the solidifying magma had at any given time nearly the same composition. Thus the surface of first ore-deposition must have been, in effect, an isothermal surface enveloping the igneous mass. As the solutions altered in composition, presumably becoming less and less rich in gold and sulphides, the surface of first ore-deposition migrated farther and farther from the stock, and this in spite of

* Van't Hoff, J. H.: "Physical Chemistry in the Services of the Sciences," 1903, p. 123.

a contrary tendency due to falling temperature. Thus it is probable that ore will not approach so nearly to the mass from which it originated in the poor as in the rich shoots. There must also have been in each fissure a temperature so low that the solutions were no longer able to contain constituents capable of depositing ore. This point may have been at the actual surface, and its position was certainly as much dependent on the land-surface as the point of first ore-deposition was upon the igneous contact. This question, however, is not of much importance, seeing that denudation has in the Reefton Subdivision removed so great a thickness of rock that the intermediate zone containing the ore is now at the surface, or has already been entirely eroded.

Rocks are bad conductors of heat, and the temperature gradient must steepen markedly in the neighbourhood of a freezing magma. It is to be expected that an ore-deposit formed where the isotherms were close together will show much more pronounced variation than one formed in rock where they were wide apart. This affords a plausible explanation of the fact that the Alpine lode, which is contained within slightly metamorphosed greywacke, shows decided variation in 600 ft. of depth, while no change in gold-content can be detected in any of the shoots near Reefton, although half a dozen have been mined 1,500 ft. or more below the surface. It seems logical to conclude that until the metamorphic aureole of the granite is reached the gold in the quartz veins will not show pronounced diminution: in fact, the data furnished by the lodes near Reefton are against any impoverishment at all so long as the country remains unaltered. But account must be taken of experience in other mining districts, and this is to the effect that even such persistent lodes as are here considered will decrease in value, though very slowly, as depth is attained.

It would be expected that within the zone of ore-deposition there would be a particular horizon which would be more favourable for the formation of ore than any other, either above or below. This is known to be the case for some metallic ores, but experience seems to show that general impoverishment of primary auriferous ores is always downward.* Thus, for such a lode as the Alpine it may be argued that its upper portion, now denuded, within the unaltered greywackes was probably slightly richer than the average ore actually mined, and that the ore-bodies were comparable with those found in such high-grade shoots as those of the Boatman's, Ajax, Big River, and Blackwater groups. Equally the lodes of these groups will probably contain profitable ore to well within the metamorphic zone. Not even a guess as to the depth the granite lies below the present surface can be given for any particular series of lodes. Concerning the lower-grade shoots—such as are contained in the Crushington, Globe, and Merrijigs groups—little can be said. Probably quartz attractive to the miner will not penetrate so deep as in the case of the richer shoots, but, as there are no data by which any absolute depth may be determined, such a statement as to relative depth has no practical value. Comparison with other mining districts must be used with caution, for it is doubtful if identical essential features are present in any two regions. Those which seem most nearly to resemble the Reefton area are Bendigo in Victoria, the Mother Lode region of California, and Kolar in India—districts where profitable ore has been won at depths twice that from which it has yet been extracted in any mine near Reefton.

Rock-temperatures.

During the examination of the underground workings a number of rock-temperatures were taken, those from the Blackwater Mine being observed by Mr. F. K. Broadgate and those from the other localities by the writer. The thermometer was

* But see remarks on blind shoots on p. 176.

left in the hole from fifteen to twenty minutes in each case. In the limited time available it was not possible to select bores presenting uniform characteristics as to depth, length of time drilled, nature of rock, or position in respect to new ground. In the circumstances it is surprising that the temperatures are so generally concordant. The data in the case of the Progress and Big River mines are too scanty to be of use; and if the figures relating to them, together with temperatures Nos. 6 and 23, which are evidently anomalous, be ignored, the depths to be sunk in the Keep-it-Dark, Wealth of Nations, and Blackwater mines to attain an increase of 1° C. are respectively about 120 ft., 145 ft., and 165 ft. In general, in the Reefton district the rate of increase in temperature is 1° C. for each 150 ft. of depth.

Table showing Rock-temperatures, Reefton Mines.

Mine.	Locality.	Depth of Hole, in Feet.	Bored in	Time bored.	Depth below Shaft-collar, in Feet.	Distance from nearest Surface, in Feet (approx.).	Temperature, in Degrees C.
1. Blackwater ..	No. 2 level	5·0	..	18 hours	175	150	14·25
2. ,, ..	No. 3 level	5·5	..	3 days	300	270	15·50
3. ,, ..	No. 3 level	6·0	..	12 hours	350	330	15·75
4. ,, ..	No. 4 level	3·0	..	6 months	615	600	17·00
5. ,, ..	No. 4 level	3.0	..	5 months	700	670	17·25
6. ,, ..	No. 5 level	4·0	..	2 hours	765	740	16·25
7. Progress ..	No. 7 (E. crosscut) ..	4·5	Mullock ..	..	975	800	18·80
8. Blackwater ..	No. 6 level	5·0	..	1 hour	925	900	19·25
9. Progress ..	No. 9 level (E. drive) ..	5·5	Fault-breccia	1 month	1,116	940	19·50
10. Wealth of Nations	No. 6 level (N.W. cross-cut)	4·0	Mullock ..	4 hours	1,219	1,020	19·50
11. Keep-it-Dark ..	No. 7 level (E. crosscut)	4·5	Greywacke	12 hours	1,024	1,060	20·20
12. Progress ..	No. 10 level (E. drive)	3·5	Mullock ..	..	1,266	1,100	19·50
13. ,, ..	No. 10 level (S. block) ..	4·5	Ore ..	2 hours	1,266	1,100	19·50
14. Keep-it-Dark ..	No. 8 level (intermediate)	4·5	,, ..	6 hours	1,195	1,125	22·20
15. Wealth of Nations	No. 7 level (N. crosscut)	3·5	Mullock ..	2 days	1,344	1,150	20·80
16. Progress ..	No. 11 level (Magazine drive	4·0	Greywacke	4 years	1,416	1,240	22·00
17. Wealth of Nations	No. 8 level (N.W. cross-cut)	3·0	Mullock ..	3 hours	1,469	1,270	21·50
18. Keep-it-Dark ..	No. 9 level (main cross-cut)	..	Greywacke	8 hours	1,345	1,300	22·25
19. Big River ..	No. 10 level	2·5	Mullock ..	4 days	1,575	1,380	21·50
20. Wealth of Nations	No. 9 level (N.E. cross-cut)	4·5	Greywacke ..	4 hours	1,594	1,400	23·00
21. ,,	No. 10 level (No. 3 S. connection drive)	..	Ore ..	2 hours	1,670	1,470	23·00
22. ,,	No. 11 level (No. 2 block rise)	3·0	Wet ore ..	1 hour	1,818	1,620	24·00
23. ,,	No. 12 level (main cross-cut	4·0	Greywacke	16 hours	2,120	1,900	24·40

Caledonian Group.

History.

The Caledonian lode was discovered outcropping on the south bank of Larry Creek, early in 1872, by Joseph Potter and Thomas Bateman; but the locality was so remote that, had it not been for the rich returns from the Just-in-Time and Fiery Cross claims at Capleston, it is doubtful if the district would have received as early attention as it did. Other claims were quickly pegged out, and in spite of immense difficulties a 10-head crushing plant was erected by the No. 2 South Larry's Quartz-mining Company, which held ground south of the Caledonian, on the same lode-series. Crushing was commenced in 1874 by both the companies named, with satisfactory results, the Caledonian paying a dividend and the No. 2 South Larry's liquidating the greater part of the debt incurred on the machinery. For a few years operations were successful, but in the 1877 the rich ore of the No. 2 South Larry's was exhausted, and a like fate overtook the Caledonian two years later. In 1879 the two claims merged into the Caledonian Extended, which at first vigorously prospected the ground, but carried out their operations later in a desultory way, and finally abandoned the ground.

In 1894 a private company, in which Messrs. B. and R. Duffy were the principals, took up the ground, erected a 5-head battery, and crushed the small block of ore left to protect the shaft, and a considerable amount of the old dump, with fair results considering the size of the plant. In 1895 this property with many others in the district was acquired by Mr. David Ziman, who later transferred it to the Consolidated Goldfields of New Zealand. No attempt was made to reopen the shaft, although much money was spent in retimbering old adits, and, the prospects being considered unsatisfactory, the property was in 1900 once more abandoned.

In 1906 a syndicate in which the brothers Duffy were interested began the sinking of a new shaft on the north bank of the river. A company, the New Caledonia Goldmining Company, acquired the rights, and with the aid of a subsidy from the Government, after many delays due to the amount of water encountered, succeeded in sinking the shaft to a depth sufficient to command untried ground. Prospecting operations, however, were unsuccessful, and in 1910 the company collapsed.

Workings.

The original Caledonian Company sank a shaft, 8 ft. by 4 ft. in the clear, on the south bank of the river, close to the point of discovery, to a depth of 183 ft., and from it four short levels were driven. Water-power was used for pumping and winding. The first crushing yielded at the rate of 9 oz. per ton, but subsequent crushings were poorer, reducing the average of the ore from the mine to about 4 oz. per ton. The ore-shoot had a steep easterly dip, and pitched to the north at about 30°. It had an average length of about 180 ft. and a width of 3 ft. No. 3 level yielded little ore, and No. 4 none at all; and from the description given by Mr. G. G. P. Wise, sometime legal manager of the claim, the writer has little doubt but that the shoot was cut off by a fault, a conclusion supported by the fact that the country rock of this locality is shattered and fissured, and allows much water to enter the workings. The second shaft, sunk north of the river in 1908–9, reached a depth of 285 ft., and a level was driven 42 ft. below the lowest workings of the old shaft. A well-slickensided plane was cut and driven on for about 300 ft. From this two crosscuts were driven under the old workings, but, beyond cutting the track on which No. 4 level of the old shaft had been driven, nothing was discovered, and work ceased. The lode-channel in No. 3 level strikes about 155°, with a steep easterly dip, while the fault-plane in the new shaft strikes 125°, and dips vertically. This fault-plane lies about 120 ft. north-east of the point in No. 3 at which the lode was cut off by a second fault. The block of ore worked by the old company must be considered as the upper portion of a shoot, of which the downward extension lies to the north-eastward of the fault-plane explored from the new shaft. A block of ore, however, should lie between the fault-planes, and there is little doubt that if prospecting operations had been more vigorously undertaken from the new shaft level something of value would have been found.

No. 2 South Larry's Claim was originally developed by an adit, over 600 ft. long, driven to the lode. Where struck the lode was 12 ft. wide, and consisted of a "mullock reef"—that is, small leaders of quartz, which in this case carried visible gold, thickly interspersed through slate and sandstone, the whole formation having but ill-defined walls. The first crushing yielded 18 dwt. per ton, but the ore depreciated in value both overhead and underfoot, so that the average from the mine was about 11 dwt. per ton. The lode-channel was driven on both north and south, and three large ore-shoots were proved and worked to the surface. These shoots dipped steeply to the eastward, and pitched northward at about 27°. The lowest workings in this claim are from the Argyle tunnel, 40 ft. below the main adit of No. 2 South Larry's, and driven during 1883–84. Here the ore, although much more compact, was of decidedly lower grade (yielding in the battery under 3 dwt. per ton), and could not be worked at a profit. Some dislocation of the country has evidently taken place at this point, for the majority of the leaders and tracks dip to the westward, whereas in the upper workings the dip was consistently to the eastward. The data available are so incomplete that the writer hesitates to recommend the reopening of the lowest tunnel, although it is by no means certain that the impoverishment of the ore is of a permanent nature.

A great deal of surface prospecting has been undertaken both north and south of the claims here dealt with, but nothing of importance has been found.

A table showing the returns from the Caledonian group of mines is printed on page 133. The official reports from which this and similar tables have been compiled do not contain the tons crushed and ounces obtained for the years ended 31st March, 1880 and 1885 respectively.

Italian Gully Group.

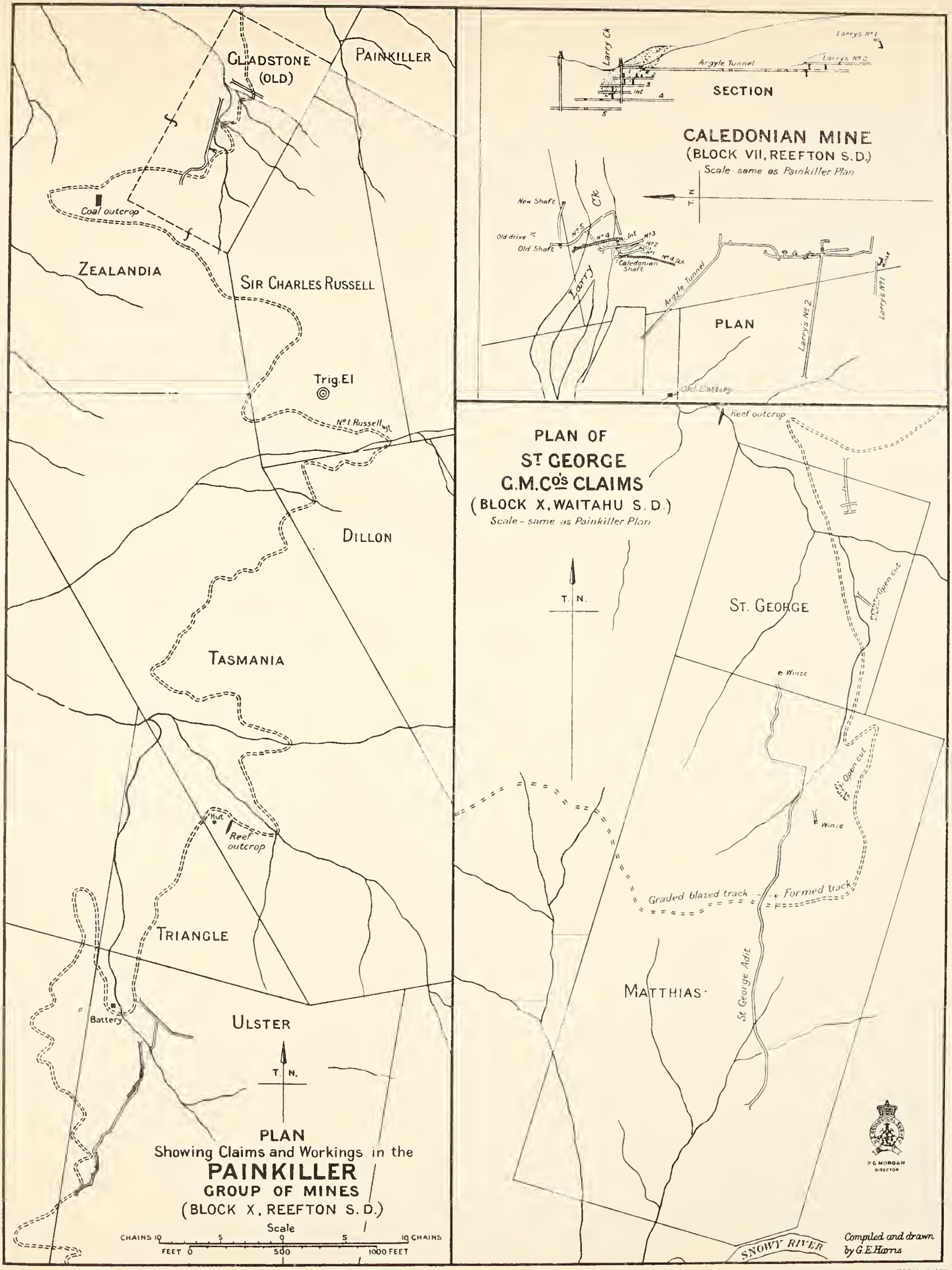
History.

An auriferous lode was discovered in Italian Gully by Francis Walker at about the same time as Potter found the Caledonian. The quartz vein was vigorously prospected, a 5-head battery was erected near the junction of Raglan Creek, and crushing began in 1876. It had been anticipated that the ore would give returns similar to those of the Hopeful lode, and the actual yield, though nearly an ounce to the ton, was very disappointing and unpayable. The company struggled on for a while longer, but in 1878 disposed of the claim and plant to the Golden Arch Company. No better results were obtained, and in 1883 a tribute was let, and next year the ground was abandoned.

Some prospecting was done in this locality in 1894, but it was not until 1905 that another serious attempt was made to work the original claim. In that year Knight and party cleaned out the low level, and erected a small steam-driven 5-head mill close to the mouth of the tunnel. In 1907 a crosscut of 100 ft. from the main level cut a heaved portion of the lode. Next year the owners, who for some time had been known as the Buller United Syndicate, disposed of their claim to the Golden Arch Gold-mining Company, which erected a 10-head mill driven by oil-engine, and a cyanide plant. The opening-up of the low level was completed, and the lode explored for a short distance. The return of £2 10s. per ton did not pay, chiefly because the ore was small and enclosed in very hard walls. The claim was worked by tributers with considerable success for some time before the company went into liquidation.

Workings.

No plans of this mine are available to the writer, but the shoot is known to be at least 500 ft. in length, with an average thickness of 6 in. to 8 in., which expands in one place to over 3 ft. The strike is approximately 10° west of north, and the dip is eastward at about 70°. The position of the wide portion of the lode in the various levels indicates a northerly pitch of about 35°. Four levels in all have been constructed.



PLAN
Showing Claims and Workings in the
PAINKILLER
GROUP OF MINES
(BLOCK X, REEFTON S.D.)
Scale
CHAINS 10 5 0 5 10 CHAINS
FEET 0 500 1000 FEET
T. N.
GLADSTONE (OLD)
PAINKILLER
Coal outcrop
ZEALANDIA
SIR CHARLES RUSSELL
Trig. E1
No. 1 Russell
DILLON
TASMANIA
Hut
Reef outcrop
TRIANGLE
Battery
ULSTER
CALEDONIAN MINE
(BLOCK VII, REEFTON S.D.)
Scale same as Painkiller Plan
SECTION
Larry Ck
Argyle Tunnel
Larry's No. 1
Larry's No. 2
Int
PLAN
New Shaft
Old drive
Old Shaft
Caledonian Shaft
Larry Ck
Argyle Tunnel
Larry's No. 2
Larry's No. 1
Old Battery
PLAN OF
St GEORGE
G.M.Co's CLAIMS
(BLOCK X, WAITAHU S.D.)
Scale - same as Painkiller Plan
T. N.
Reef outcrop
ST. GEORGE
Open cut
Winze
Open cut
Winze
Graded blazed track
Formed track
MATTHIAS
St George Adit
SNOWY RIVER
P.G. MORGAN
DIRECTOR
Compiled and drawn by G. E. Harris

700.9.15.635

of which the three upper are driven from a small creek directly on ore. The lower adit crosses country for some hundreds of feet before striking the lode, which it follows north and south, in all about 500 ft., while ore of average size and tenor still shows in the face at either end. A fault striking about 20° east of north, with a steep easterly dip, crosses the lode south of the point at which the crosscut enters, and heaves it about 100 ft. to the westward. Other dislocations, probably subsidiary to the first, occur farther south, and their displacements, though small, add considerably to the cost of mining. Their tendency is to shift the lode to the westward again.

The only other claim on this lode-series that has received attention is the Garibaldi, which lies to the south of the Golden Arch and within the basin of Burk Creek. The brothers Coghlan did some prospecting here in the "nineties," and proved an ore-shoot of a width and value similar to that occurring in the Golden Arch Claim.

TABLE SHOWING THE YIELDS FROM THE CALEDONIAN, ITALIAN GULLY, KIRWAN, AND PAINKILLER GROUPS OF MINES.

Year ended	Caledonian.			No. 2 South Larry's.		Golden Arch, Italian Gully.			Kirwan's Reward.			Sir Charles Russell.	
	Tons.	Oz.	Div.	Tons.	Oz.	Tons.	Oz.	Div.	Tons.	Oz.	Div.	Tons.	Oz.
March 31 —			£					£			£		
1875 ..	130	463	750	2,460	1,844	..	..	..	..	..	..	..	..
1876 ..	149	375	..	3,640	1,911	..	..	..	..	..	..	..	..
1877 ..	34	136	..	1,533	322	114	109	..	..	..	..	..	..
1878 ..	120	771	1,500	244	52	240	254	..	..	..	..	..	..
1879 ..	60	200	..	..	..	159	105	104	..	..	..	..	..
1880 ..	?	107	..	..	..	?	48	..	..	..	..	..	..
1891 ..	..	..	..	..	..	..	..	..	..	..	..	17	34
1894 ..	..	..	..	..	..	..	..	..	..	..	..	11	11
1895 ..	20	20	..	..	..	..	..	..	..	..	..	470	294
1896 ..	900	97	..	..	..	..	..	..	..	..	..	383	258
1897 ..	..	..	..	..	..	..	..	..	..	..	..	90	52
1900 ..	..	..	..	..	..	..	..	..	..	..	..	25	6
Dec. 31—													
1900 ..	..	..	..	..	..	..	..	..	1,763	1,873	..	..	..
1901 ..	..	..	..	..	..	..	..	..	2,822	2,290	3,500	..	..
1902 ..	..	..	..	..	..	..	..	..	3,963	2,548	5,600	..	..
1903 ..	..	..	..	..	..	..	..	..	4,814	1,791	2,100	..	..
1904 ..	..	..	..	..	..	..	..	..	6,250	1,950	..	..	..
1905 ..	..	..	..	..	..	50	14	..	7,584	1,684	..	..	..
1906 ..	..	..	..	..	..	50	55	..	2,354	522	..	..	..
1907 ..	..	..	..	..	..	65	50	..	..	..	..	..	..
1908 ..	..	..	..	..	..	..	..	..	..	..	..	146*	99*
1909 ..	..	..	..	..	..	307	219	..	230	40	..	234*	142*
1910 ..	..	..	..	..	..	74	63	..	..	..	..	..	..
1911 ..	..	..	..	..	..	30	33	..	..	..	..	..	..

* Returns from the Ulster Claim.

KIRWAN GROUP.

History.

In December of 1896 William Kirwan while on a prospecting expedition discovered that loose gold-bearing quartz, often in large blocks, covered an area of several acres, at a height of about 3,600 ft., on the flanks of a mountain which afterwards received the name of Kirwan's Hill. Prospecting proved that large quartz veins, from 3 ft. to 6 ft. wide, traversed the country north-east of the find, but in none was the gold-content even approximately equal to that of the loose quartz. In October, 1897, the Anglo-Continental Company acquired an option over a group of leases in this locality, and vigorously prospected for the solid lode by means of adits and winzes. Their efforts, however, were unsuccessful, and in 1898 the option lapsed, although the company retained a third interest in the Kirwan's Reward Gold-mining Company, which was then formed to erect a mill and crush the loose surface ore. By June of 1900 a 10-head water-driven mill had been erected, connected with the claim by an aerial tram, and crushing shortly commenced. In 1902 another 5 heads of stamps were added to the battery, which, besides amalgamating-tables and berdans, had the old-fashioned blanket strakes as the only concentrating appliance. Nevertheless the oxidized ore was of so free-milling a nature that the tailings from the mill compared most favourably in lowness of gold-content with those from other mills in the district. During the winter months the heavy snow and severe frosts consequent on the high altitude stopped all work in the open-cuts which yielded the ore. In 1907 the quartz became exhausted, and the property was acquired by Mr. P. N. Kingswell, who, after a period of unsuccessful prospecting, sold the plant and claim to Pettigrew and party in 1909. This syndicate, after putting through a small trial crushing with unfavourable results, concentrated their energy on prospecting, and have now driven a low-level adit over 2,000 ft. in length, intended to explore the ground beneath the old open-cuts, at a depth of more than 1,000 ft. beneath the lowest workings.

The numerous veins of this locality at one time or other have received a great deal of attention from prospectors. During 1897–98 at least a score of claims were actively prospected, and gold-bearing lodes were located in several of them, of which perhaps the Newhaven yielded the least discouraging results. In 1911–14 this lode was again systematically tried and abandoned by the Hit-or-Miss syndicate.

In 1905 Kirwan and party discovered a gold-bearing quartz vein about a mile up the small creek which enters the north branch of the Waitahu, nearly opposite Kirwan Creek. The lode was too broken for serious exploitation, although the quartz assayed satisfactorily, and the claim, known as the Main Reef, was soon abandoned. The lode, which is reported to be about 30 in. in width, was driven on for 70 ft. or more, and a winze was sunk. The workings, which were not visited, lie without the boundary of the subdivision, and therefore are not shown on the maps.

Workings

The open-cuts from which the ore crushed by the Kirwan's Reward Company was won occur over an irregular area 20 chains by 15 chains in the Lord Brassey Claim. Altogether it was found that at a depth of about 120 ft. below the original surface the loose broken material became too deficient in quartz fragments to pay for working. Numerous winzes and tunnels, often hundreds of feet in length, were constructed in order to explore the shattered zone, but no plan of these workings is available, and the same must be said concerning the Newhaven and Hit-or-Miss claims. In 1901–2 a tunnel over 500 ft. in length was driven from the head of a branch of Larry Creek, for the purpose of exploring in depth a lode that outcrops along the western shoulder of Kirwan's Hill, and from which a large block of rich ore found in the creek was considered to be derived. Nothing was cut in this tunnel, which will need to be produced another 1,000 ft. at least to accomplish the object desired. The tunnel being driven by Pettigrew and party from the upper valley of Kirwan Creek had at the time of the writer's visit reached a length of 1,460 ft., but by July, 1915, had penetrated about 2,000 ft. For the first 1,400 ft. the country was very wet and shaken, but for the remainder of the distance driven was much more solid. Numerous leaders and a few fair-sized quartz lodes have been cut, but of these most are quite barren and the rest are unpayable. The strike of these lodes in general is west of north, and the dip easterly.

The extraction of the broken quartz from the open-cuts proved that the ore lay on or near the surface in the western portion of the ground worked, while to

Joker
Lord Glasgow
Ben Tillet
Larry Creek
Special Site
Bret Harte
Colonial
Trig KH
Mt. Kirwan
4247'
Emancipator
Morgan
Pilgrim
Surplus
Golden Pebble
Governor
Artemus Wa d
Sam Slick
Lord Nelson
Holy Terror
Hut
4200'
4030'
Earl Brassey
Newhaven
4150'
Winze
Hidden
Mystery
3860'
Lady Brassey
Mark Twain
3900'
XII
XVI
Napier
3730'
Hotel
Ki wan's
Reward
ide-de-Camp
T N
3540'
Hopper
Lord Brassey
Kirwan Creek
3300'
Approx boundary of open workings
Young N. Z.
Mutual
3100
2290'
Aerial Tramway
2700
Big Reef
Mt Victoria
Lady Agnes
2900'
to Waitahu R.
2250'
1900'
2100'
Leader
Battery
1650'
Lady
Antrim
Lucks Way
Waitahu
P.G. Morgan
Director
Trig. Z.
City of Derby
Ivanhoe
Lucky
Eldorado
Reef Outcrops shown thus
PLAN
Showing Claims and Workings
in the
KIRWAN'S HILL
GROUP OF MINES
(BLOCKS XII & XVI, REEFTON S.D.)
Scale
10
0
10
20
30
40
50 CHAINS
FEET 1000
0
1000
2000
3000 FEET

700.9.15.632

the north-east it was overlain by a thick layer of rubble, and this in spite of the fact that in this locality the surface is some hundreds of feet lower than the western end of the claim. It was not uncommon to find fragments of lode enclosed in country which closely resembled that of the other lodes of this locality. McKay* states that the lodes strike south-south-east, but the writer's observations go to show that when unaffected by faulting they strike east of north. Several powerful fault-zones striking west of north traverse this region, and near them the orientation of the lodes conforms more or less with that of their strike. From these facts as premises the conclusion may be drawn that the deposit worked originated through a large auriferous lode, striking east of north, with an easterly dip and northerly pitch, becoming involved in the shatter-zone of a powerful dislocation striking north-west and dipping south-west. The downward continuation of the shoot should then exist to the north-eastward, and probably crosses portions of the Mark Twain and Kirwan's Reward claims into the Earl Brassey and Newhaven ground. It is significant that the only reefs found in this locality not absolutely barren traverse these claims, and it is not unreasonable to consider them shoots of poorer ore on the same lode-channel as that carrying the shoot which furnished the rich broken quartz. It is probable that this shoot will nowhere reach the surface in the claims mentioned. If these conclusions are correct the extensive prospecting operations of Pettigrew and party will certainly not achieve their primary object.

Capleston Group.

History.

In the Boatman's district the first discovery of an auriferous lode was made in January, 1872, by Axel Topfer, on a claim called the Boatman's Creek, that later formed part of the Just-in-Time. Other discoveries quickly followed, the Just-in-Time (west reef) by James Clarke, the Alexandra, the Fiery Cross by Messrs. M. and J. Ryan, the El Dorado by P. Q. Caples, and the Hit-or-Miss (better known as Specimen Hill) by Thomas Gaffney. In 1873 the Just-in-Time and Fiery Cross companies jointly built a water-driven 15-head battery. The first crushing was of 308 tons from the Just-in-Time lode, and the yield of 1,631 oz. was most opportune, in that it restored public confidence then waning by reason of the poor returns from the Murray Creek mines. The Fiery Cross in the same year, although crushing ore much less valuable, obtained sufficient gold to provide a dividend as well as to pay for its share of the mill. In 1874 the eastern lode of the Just-in-Time was found, and the energies of the company were directed to its exploitation. For many years the Fiery Cross and Just-in-Time were two of the most important mines in the Reefton district. Each worked one of the great ore-shoots developed along the main lode-channel of this locality, and each absorbed adjoining claims in which only parts of these shoots could be found near the surface.

In 1875 a third rich shoot lying to the north along the same channel was attacked by the Hopeful Company. This, the richest shoot in the Reefton district, was discovered early in 1872 by the brothers Ryan. The first applicant for the claim was Henry Chaplin, and the date of registration of the company 12th April, 1872. By 1879 the Hopeful had distributed over £40,000 in dividends; while two years before, the Welcome, registered 20th August, 1873, and working the same shoot, had also begun to pay dividends. For ten years the Welcome was the most consistently profitable mine in the Reefton district, distributing during this period more than £100,000 in dividends on a paid-up capital of £3,750.

* McKay, Alex.: "Report on the Auriferous Rocks of the Western Slopes of the Victoria Mountains, Nelson." Mines Report, 1898, C.-9, p. 2.

The year 1881 was an exceptionally prosperous one for the district, and as a consequence much prospecting was done in the Boatman's area. Rich ore was found in another shoot on the main lode-channel, this time to the south of the Just-in-Time shoot. This find, made in the Imperial Claim (late Alhambra, late Rose of Lancaster), proved of small importance, and although the shoot was in subsequent years explored by the Reform and Just-in-Time companies no valuable ore-bodies were discovered. Another claim, the Specimen Hill, also got good ore. The claim was originally called the Hit-or-Miss, was afterwards known as the Lucky Hit, and later as the Crœsus. On the same lode-series, farther to the south, are the Pactolus, prospected by Henry Evans in 1878, the Lady of the Lake, and the Argus.

For the year ended 31st March, 1882, the Welcome distributed no less a sum than £34,500 to its shareholders; and, since it was known that the pitch of the lode would shortly take the continuation of the rich ore-bodies out of the Welcome ground, two projects were initiated during that year to develop them in depth. The Eureka, after many objections from the Fiery Cross and Welcome companies, commenced the construction of an inclined tunnel, the workings from which ultimately penetrated to the desired position. The second project consisted in the driving of a low-level adit from Little Boatman Creek in such a direction and to such a distance that a shaft sunk near its end would command the Hopeful-Welcome lode beyond the Welcome ground. As this tunnel when constructed would cut across the trend of the lodes in this locality, prospect several claims in depth, and provide ready access to any blocks of ore that might be found in them, the Occidental, Welcome No. 2, Homeward Bound, Specimen Hill, North Cleopatra, Comstock, and Great Eastern companies, holding claims on or near the line of the tunnel, all contributed to its cost. Most of these companies were defunct long before the completion of the adit, which was finished in 1886 by the Homeward Bound and Specimen Hill at a total cost of about £5,000, of which £300 was paid by the Mines Department as a subsidy.

Rock-borers came into general use in the Boatman's district in 1883, when the Eureka erected a steam-driven compressing plant at the mouth of the incline tunnel, while a turbine-driven installation supplied air to the drills of the Specimen Hill adit. The Welcome Company in the same year excavated a large chamber at the end of their lowest adit (No. 6), and placed in it boilers and a winding-engine and an air-compressor. A flue 800 ft. in length conducted the smoke and exhausted air from the mine to the surface through their own and the Hopeful old workings. A shaft was sunk, which by 1887 had attained to a depth of 430 ft. below No. 6 adit. Ore could not be found at this depth; and the subsequent history of this and the immediately adjoining mines is made up of a series of attempts to find the continuation of the Welcome shoot. Thus the Eureka by 1888 had expended £18,000 in one unsuccessful attempt, while the Homeward Bound had sunk a shaft from the end of the Specimen Hill adit, to a depth of 300 ft., in another. The Welcome struggled on without result until 1892, when the long-talked-of amalgamation with the Homeward Bound and Eureka companies was effected, and from this date until the claims were acquired by the Consolidated Goldfields in 1897 prospecting operations were carried on from the Eureka workings only. In 1893 a fire broke out in the underground chamber at the top of the Welcome shaft, and plant there placed was completely destroyed.

The directors of the Just-in-Time and Fiery Cross mines conducted the financial operations of their companies in a manner differing in no wise from that of the other claims in the Reefton district. After a block of ore had been discovered prospecting ceased, and all the energies of the staff were utilized in the extraction of the ore-body, while profits were distributed as quickly as they accrued. That the returns from the mines and the dividends declared were erratic was not to be wondered at, and the reader may readily reconstruct the general history of each mine from the table on page 142. Prior to 1882 the Just-in-Time had obtained its ore by means of long adits and winzes therefrom, but in 1883 a shaft was sunk in conjunction with the Imperial Company close to their mutual boundary. The Imperial (later the Reform) at no time developed a profitable ore-body, but the Just-in-Time found highly payable quartz in their 200-ft.-shaft level from a block quite close to the northern boundary of the claim. The pitch of the lode carried it below this level into the adjoining Fiery Cross ground, where it was worked with great profit. By 1889 the ore-body in the Just-in-Time had become exhausted, and the company collapsed in 1891.

The Fiery Cross in the early days showed great vitality. In 1887 it absorbed the Alexandra and in 1888 the Hopeful Extended. From this latter claim splendid returns had been obtained for a few years, before its ore-shoot passed into the Welcome ground; and after years of desultory prospecting, during which tributes were let on several occasions and one reconstruction took place, the company lost its identity. The Fiery Cross had fewer vicissitudes than the Just-in-Time. For many years the ore came entirely from the Fiery Cross shoot, but in 1887 what is indubitably the Just-in-Time shoot was struck in the 450 ft. level. While this shoot was undisturbed regular dividends were paid, but as soon as an unfavourable condition was encountered the expense of handling the waste rock, incidental to the means of access adopted, soon forced the company into liquidation. This occurred in 1893, when the plant and claim were purchased by Rooney and party. A block of ore considered by the company of too low a grade for profitable extraction was worked with success for nearly two years, but the mine had been doing badly for some time when Mr. D. Ziman purchased it in 1895.

The claim held by the Specimen Hill Company was one of the most disappointing in the whole district. The surface was strewn with blocks and fragments of quartz, often richly auriferous, and the numerous trenches and prospecting-drives seldom failed to disclose "tracks" carrying boulders of ore. In 1881 what was considered a good find was made, and next year a battery was erected in Little Boatman Creek. Returns, however, were most disappointing, and this, combined with the erratic nature of the ore-bodies, led ultimately to the abandonment of the claim in 1893.

In 1880 John Devereux prospected a claim known as the Orlando situated close to Trigonometrical Station CC, on the ridge between Boatman Creek and the Waitahu. The writer could not ascertain if auriferous ore was obtained here, and on visiting the locality concluded that the prospecting trenches and drive had followed a fault-plane in Devonian quartzite.

In 1885 John McCafferty found ore in the Lone Star Claim, which appears to be directly on the line of the main Boatman's lode-channel. Next year a company was formed, which drove several adits and spent much money without locating a persistent ore-body. In 1888 an aerial tram was erected, and what ore had been broken was crushed at the Just-in-Time battery. The yield was disappointing, and the company was wound up shortly afterwards.

The first crushing plant erected in the Boatman Creek district allowed the tailings to run directly into the sludge-channel. Blanket strakes, however, were soon introduced, and the concentrates were reground with mercury. In 1880 the Welcome erected a new 10-head mill fitted with berdans, and in the same year the retreatment of tailings in the Just-in-Time - Fiery Cross mill was attempted. There is little doubt, however, that at least 50 per cent. of the gold was lost, and the writer considers this a moderate estimate when the coarseness of the gratings used and the amount of stibnite in the ore are considered. In 1893 the Cassel Gold-extraction Company erected a small cyanide plant at Capleston to treat the accumulations of tailings there. The amount of slimes and stibnite present militated against success, and towards the end of 1894 the company withdrew from the field. In later years, 1903–5, after the conditions requisite for success had become known from the operations of plants in other parts of the Reefton district, the New Welcome Company successfully treated the tailings from its plant.

In 1895 Mr. David Ziman acquired the Just-in-Time and Fiery Cross claims as well as other ground in the neighbourhood. Later the Welcome United also became his property, and under the auspices of the Consolidated Goldfields of New Zealand a new company with a working capital of £15,000 was formed to develop the ground. A crosscut was driven from the Eureka incline, and Nos. 4, 5, and 6 adits of the Welcome were cleaned out and retimbered. A new block of ore was discovered at the northern end of No. 5, and energetically developed. The Specimen Hill adit was next reopened, and a crosscut projected to cut the new ore-body at that level. Connection with No. 5 was established in 1900, but the new shoot could not be traced to the level of the adit; and after all the ore had been removed and treated at a 5-head battery, and small cyanide plant erected near the mouth of the main tunnel, the mine was let on tribute for a few years, and the claim finally surrendered in 1907. Meanwhile the Consolidated Goldfields cleaned out No. 4 level of the Fiery Cross and the 200-ft.-shaft level of the Just-in-Time Claim. In 1899 the Just-in-Time shaft was deepened to 400 ft., and the Imperial shoot explored at that level. This ore-shoot, that had years before been found valueless, did not belie its reputation, and after a period of unsuccessful tributing the claims were surrendered and the crushing plant dismantled.

The Welcome Claim was immediately taken up after its surrender, and after a lengthy period of prospecting a company was formed to test the ground. This company, however, shortly collapsed. The Just-in-Time ground also received attention from prospectors, and on the 6th August, 1910, a company was registered which reopened the mine and did a considerable amount of prospecting in the two shaft levels. Nothing in the nature of a payable block was discovered, and in 1910 the company went into voluntary liquidation. Recently the Welcome, Fiery Cross, and Just-in-Time claims have come under one ownership; and the promise of £10,000 subsidy having been obtained from the Government, a renewed attempt to form a company financially strong enough to explore the deep levels was successfully made, and mining operations begun.

Workings.

Welcome United and Hopeful Mines.—The Hopeful-Welcome shoot was in its upper portion exploited by adits driven northward from Caples Creek, and in this manner a depth of nearly 600 ft. below the outcrop was attained. The lowest or sixth adit, however, had to be driven more than 2,000 ft. before striking the ore-body, and it became evident that further development would have to be by a different method. Accordingly a vertical shaft 9 ft. by 4 ft. in the clear was sunk at the end of No. 6 adit, nearly 3,000 ft. from daylight. This ultimately reached a depth of 430 ft., and from it three levels were driven. In the lowest level (No. 9) no ore could be discovered; and for this reason, and from the fact that the workings were then very close to the claim boundary, the shaft was not sunk deeper. These workings showed that the ore-shoot had a length on the horizontal of nearly 600 ft., with an easterly dip of 66° and a northward pitch of about 32°. The thickness of the ore averaged perhaps 30 in., but occasionally was as much as 7 ft. That the ore-shoot has a greater linear extent than that here allowed it, or that another shoot existed on the same lode-channel, was proved in 1897, when No. 5 level was extended northward on ore 220 ft. beyond the limits as previously determined. This block was not traced downwards below No. 6, while upward it had been removed by denudation.

So far only the Hopeful-Welcome workings, properly so called, have been considered. Other groups of underground workings designed to exploit the main ore-shoot at a greater depth exist in the Specimen Hill - Homeward Bound and Eureka tunnels and shafts. Thus the Specimen Hill adit, about 40 ft. below No. 6 level, penetrated a distance of 2,300 ft. from daylight; and at this point, just on the edge of the Homeward Bound Claim, a vertical shaft was sunk to a depth of 300 ft. Gold-bearing quartz is reported to have been cut by this shaft, but no prospecting operations were conducted upon it. The Homeward Bound Company did a little unsuccessful prospecting from No. 9 level Welcome, and from the intermediate above it. The New Welcome Company, formed in 1898, drove a branch tunnel from a point about 1,500 ft. from the mouth of the adit, 1,200 ft. in length, to explore the country beneath the ore-body developed in No. 5 level north, but found nothing. A rise was put up connecting the adit with No. 5 level, and the ore worked in this part of the mine was taken out by this route. The Eureka workings consist of a tunnel 1,800 ft. in length, inclined at an angle of about 18° from the horizontal. From the bottom of the incline the tunnel was continued horizontally for 660 ft., and from this point a vertical shaft or winze was put down, and levels driven at depths of 243 ft. and 533 ft. A considerable amount of prospecting was done from these levels, chiefly along "reef-tracks," and connection was made with the old Welcome workings. Crosscuts were also driven from the incline westward to explore the lode-channel between the Welcome-Hopeful and Fiery Cross shoots. These operations were not successful in locating an ore-body, and prospecting was ultimately abandoned.

An inspection of a plan and section of the Welcome-Hopeful workings makes it obvious that the ore-shoot has been displaced by a fault. The shoot contracts in width below No. 7 level, and may be said to die out at No. 9 level. The minor displacements which generally accompany a fault seem to have first appeared in No. 6 level and continued throughout to No. 9. "Stone is found in detached blocks along the line of reefing country for 600 ft. to 700 ft., and runs in narrow seams rich in gold; but it is much broken up by hard sandstone bars which cross the course of the reef."* A similar condition obtained throughout the ore-body developed in No. 5 level north, and this was also cut off to the north, and could not be traced as far down as the level of the Specimen Hill adit. Concerning the country beyond the limits of the ore-bodies, there are numerous references in the reports of the Wardens and Inspectors of Mines of "tracks" filled with the black pug and quartz fragments so characteristic of faults in the country of the lodes in the Reefton district. These facts establish that the Hopeful-Welcome shoot has been faulted, and that before entering the zone of intense faulting in which the ore-bodies were completely shattered it went through a belt of country, about 10 chains in width, traversed by numerous minor displacement-planes. Since the underground workings are now inaccessible, and since no record of the strikes of these planes has been preserved, other sources must be sought in order to obtain this information. The main faults of this locality strike south-east, and an important dislocation separates the Miocene strata from the Palæozoic rocks a short distance to the northward. The eastern edge of this zone of faulting may be studied near the junction of Italian and Raglan creeks, at Howell's sluicing claim, and again in Burk Creek. Coal Creek, a small branch of Burk Creek, has its course entirely in the zone, which is also concerned in the crushing of the Specimen Hill ore-bodies. Near the Little Boatman - Coal Creek saddle the whole belt

* Mines Report: Official Report of Mr. Warden Bird. C.-3, 1890, p. 157.

is apparently about 20 chains in width. The fault has a downthrow to the south-westward, the amount of which cannot be precisely determined, but on topographical grounds the writer is inclined to put the movement at the Welcome Mine at about 600 ft., of which the major shift is concentrated in the eastern half of the zone of dislocation. It may reasonably be assumed that the fault-plane is nearly vertical, and there is evidence that the amount of the movement decreases towards the south. The recovery of the lost lode, although a matter of much expense and difficulty, is by no means impracticable, while the prize awaiting the judicious explorer may be very great.

Fiery Cross Mine.—No. 6 adit of the Welcome has a course of nearly 1,500 ft. through the Fiery Cross Claim before it enters the Hopeful ground. A small block in the former claim was explored from this adit, but the principal workings are approached by means of a vertical shaft. Three levels are driven from this shaft at depths of 191 ft., 300 ft., and 450 ft. respectively from the brace. The shaft, 9 ft. by 4 ft. in the clear, is near the southern end of the outcrop of the ore-shoot, which has a pitch to the northward of about 35°, and the chamber of the 450 ft. level is nearly 500 ft. in a direct line from the edge of the ore-body. Further exploitation of the shoot was undertaken by means of winzes sunk on the ore to the 553 ft. level. No doubt the directors were influenced in their choice of the method of working by the fact that the ore-shoot was at this depth very close to the Hopeful boundary, and would at a depth of 300 ft. below the 450 ft. level completely leave the Fiery Cross ground. The method of winding used at this time (1886–87) was very costly; and although the ore was of very fair quality and had been proved by winze 70 ft. below No. 5 level, the management, as soon as the Just-in-Time shoot was found in the 450 ft. level, turned their attention to the south end of the mine. Here the same penny-wise-pound-foolish method of development was adopted. An incline winding-shaft was sunk on the ore-body, and a connection made with the Just-in-Time workings. Ultimately a depth of 360 ft. on the incline was reached by this shaft, and three levels were opened from it. At this depth the shoot was interrupted by a rock floor—that is, a flat-dipping fault—which shelved gently to the northward. Similar shelves had twice before cut off the Just-in-Time shoot in the parent claim, and a like phenomenon had occurred in connection with the Welcome shoot. Thus what had happened was well understood, and had the main shaft been sunk to the 800 ft. level during the prosperous years immediately preceding the company would have been in a position to pick up the shoot without much trouble. As it was, the blind shaft was now useless, and the shareholders being unwilling to undertake the heavy expense of deepening the main shaft below the worked-out ground the company went into liquidation, and in 1893 the plant and claim were sold to a working-party. Although this party continued to extract ore from the mine for several years with success, and although the claim afterwards belonged to the Consolidated Goldfields for many years, no further development-work of value has since been undertaken.

The Fiery Cross shoot contained ore of an average thickness of between 3 ft. and 4 ft. In the upper levels the length of the shoot on the horizontal was rather more than 400 ft., but in depth it was decidedly less. The most common—in fact, the only proved—cause in the Reefton district for such a diminution in length of ore-shoot is faulting; and the writer surmises that the fault which crushes the coal-seams of Coghlan's mine at Capleston, and which from this point strikes toward the Fiery Cross Claim, here manifests itself. The few outcrops of Aorere rock on the claim indicate faulting of some kind, but nothing can be learned from the meagre reports describing the underground workings. This fault, which is of no great magnitude, is parallel to the Welcome fault, and probably has a downthrow to the eastward. It will not prove a serious obstacle to the finding of the ore-bodies at greater depth.

Just-in-Time Mine.—The larger half of the rich ore obtained from this mine was won from workings approached by adits, of which the principal were the Walhalla and Boatman's Creek adits. The "western reef" of the Just-in-Time, lying about 200 ft. to the westward of the main ore-shoot, was also attacked from an adit. The 200 ft. level of the main shaft intercepted the shoot close to the northern boundary of the claim, and no ore appears to have been extracted or exploration attempted on this shoot in the claim below this level. The 200 ft. level was also driven southward beneath the Imperial-Reform workings, but nothing of value was found; and similar remarks apply also to the 400 ft. level of this mine. The South Hopeful workings may be considered to be on the Imperial ore-shoot. The greater part of the adit was driven along "reef-track"—indeed, the only ore found was discovered a few feet from the main drive, and only 33 ft. from its portal. The stone, though rich, was but a few inches in thickness and erratically distributed along the lode-channel. The Just-in-Time shoot appears, from the available plans and sections, to have an irregular shape. The ore-bodies had an average thickness of 4 ft., and varied up to at least 10 ft. in width, while 200 ft. appears to have been their maximum length. As the shoot was followed downward gently dipping floors were met with, which cut off the ore sharply, and the workings to the lower portion of the shoot had to be carried farther eastward than the dip of the shoot would warrant. These so-called floors are, as previously mentioned, flatly dipping planes of dislocation, and probably represent minor displacements in connection with vertical faults. They were encountered at several points in the adit workings of the claim as well as in the 200-ft.-shaft level. The southern ore-bodies of the Fiery Cross, however, undoubtedly belong to this shoot, the ore corresponding closely in size and tenor with that from the Just-in-Time. Moreover, the ore-body found in the southern workings of the Fiery Cross cut out abruptly quite close above the 450 ft. level of that mine. This drift is practically at the same height above datum as the Just-in-Time 200 ft. level. Another floor dipping gently to the northward appeared in the lowest workings of the Fiery Cross, and no serious attempt has been made to locate the continuation of the ore below it. If, as has been assumed, the southern ore-bodies of the Fiery Cross are part of the Just-in-Time shoot, there is a belt of barren ground between the workings of the respective claims which can only be due to faulting. The writer suggests that what is known as the "western reef" is a fragment of the main ore-shoot moved by faulting to its present position, 200 ft. to the westward. Certainly all efforts to trace this ore-body downward have ended in failure.

The Imperial (or Reform) shoot has not been developed to the same extent as the three lodes lying to the northward along the same lode-series. The reason for this is not far to seek. No large ore-body has ever been found within its bounds, and the bulk of such stone as has been found is of low grade. Thus little information is available concerning the dip and pitch of the shoot, and what facts can be obtained may most readily be explained by supposing that a large ore-shoot carrying low-grade ore has been crushed by the fault that runs along Boatman Creek in this locality. A mere walk along the valley is sufficient to convince the most sceptical as to the existence of a fault-zone, and the only difficulty lies in the determination of its strike. The valley itself here runs parallel to the direction of well-known faults in the locality, and is continued southward by a small stream which has been proved by prospecting operations to traverse crushed country, so that the fracture-zone may be given a north-west course.

Lone Star Mine.—The lode outcrops on the ridge between Boatman Creek and the Waitahu River. A winze was sunk on the quartz, and a level driven at a depth of 67 ft. from the brace. This proved the ore-body to have a length of about 160 ft. with a thickness of perhaps 18 in. The ore, however, was very broken, and could not be found in a low level driven from the north, 170 ft. below the outcrop. Another adit at about the same height above sea-level was driven from the south side of the ridge to explore a small outcrop there exposed 350 ft. south of the main ore-body.

Specimen Hill Mine.—As before stated, the hillside on which this claim is situated was strewn with boulders of quartz often richly auriferous. A great deal of money was spent in prospecting both on the surface and by adits, and the company also contributed to the cost of the Specimen Hill low level. Five adits were driven, three of which were projected to develop a known broken and erratic ore-body, while the other two were purely prospecting ventures. The greater part of the claim lies in the powerful fault-zone which also involves the deeper portions of the Welcome shoot.

Pactolus Mine.—The Pactolus lode belongs to the same lode-series as the shattered shoot of the Specimen Hill Claim. Very little information is available concerning it, except that 108 tons yielded 498 oz. The ore-body was small and the country much shaken, nor could the vein be relocated after being lost. The Lady of the Lake (also known as the Southern Cross) and the Argus are claims on the same lode-series as the Pactolus, but farther south. Rich quartz has been found in leaders in both, but the claims have never passed the prospecting stage. The country is very shaken and wet, and is traversed by the fault that crushes the Reform shoot.

TABLE SHOWING THE YIELDS FROM THE CAPLESTON GROUP OF MINES.

Year ended	Specimen Hill.		Welcome-Hopeful.*			Fiery Cross.			Just-in-Time.†			Imperial.		Various Claims.		
	Tons.	Oz.	Tons.	Oz.	Div.	Tons.	Oz.	Div.	Tons.	Oz.	Div.	Tons.	Oz.	Tons.	Oz.	Div.
Mar. 31—					£			£			£					£
1874 ..	..	..	..	..	..	892	1,336	1,800	312	1,633	4,800	..	..	..	..	..
1875 ..	..	..	..	..	..	1,917	2,611	2,700	802	1,177	..	..	..	..	..	..
1876 ..	..	..	1,932	2,488	3,505	884	796	..	361	345	..	..	..	..	..	..
1877 ..	..	..	2,771	7,237	19,388	1,267‡	1,591‡	2,400	470	746	..	..	..	..	..	..
1878 ..	..	..	3,907	9,594	23,925	427	263	..	1,652	3,148	4,200	..	..	Pactolus		
1879 ..	..	..	5,975	11,566	19,667	1,263	1,263	..	690	828	..	..	..	98§	439§	1,000
1880 ..	..	..	?	4,559	..	?	613	..	?	1,690	..	..	..	?	62	..
1881 ..	..	..	1,100	3,209	3,750	860	859	600	938	784	700	..	..	..	..	..
1882 ..	..	..	4,084	13,531	34,500	373	464	..	736	818	700	..	..	Southern Cross		
1883 ..	..	..	4,953	7,429	15,000	..	..	..	345	314	..	811	468	21	43	..
1884 ..	940	319	3,695	4,825	1,500	2,108	2,811	3,000	..	..	..	..	..	..	..	..
1885 ..	..	..	?	?	16,500	?	?	1,200	..	..	..	..	..	..	..	..
1886 ..	..	..	1,502	2,648	..	532	504	..	47	163	..	109	107	Lone Star		
1887 ..	..	..	2,097	4,752	6,750	3,227	4,212	6,600	3,033	2,600	3,500	328	224	20	33	..
1888 ..	298	199	1,175	1,726	..	1,264	1,267	..	2,073	2,524	2,100	270	149	Argus		
1889 ..	..	..	1,005	1,759	..	2,983	2,495	3,600	453	397	..	84	74	34	48	..
														Lone Star		
1890 ..	..	..	249	731	..	1,522	1,000	..	..	..	..	70	50	200	42	..
1891 ..	..	..	144	319	..	1,722	2,302	3,225	..	..	..	..	..	..	..	..
1892 ..	..	..	255	417	..	2,431	2,818	5,643	..	..	..	..	..	Argus		
1893 ..	..	..	17	55	..	150	299	..	..	..	..	..	..	48	57	..
1894 ..	27	37	..	440	..	380	191	..	..	..	..	..	..	..	..	..
1895 ..	..	..	..	177	..	688	325	..	..	..	..	..	..	..	..	..
1896 ..	..	..	..	154	..	160	150	..	25	26	..	..	..	..	..	..
1897 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1898 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1899 ..	..	..	60	33	..	..	..	..	..	..	..	..	..	..	..	..
Dec. 31—																
1901 ..	..	..	240	497	..	..	..	..	..	..	..	..	..	..	..	..
1902 ..	..	..	1,776	1,195	..	..	..	..	..	..	..	..	..	..	..	..
1903 ..	..	..	1,611	1,144	..	..	..	..	..	..	..	..	..	..	..	..
1904 ..	..	..	380	297	..	..	..	..	..	..	..	..	..	..	..	..
1905 ..	..	..	45	53	..	..	..	..	..	..	..	..	..	..	..	..
1906 ..	..	..	118	301	..	..	..	..	..	..	..	..	..	..	..	..

* Includes yields from the Homeward Bound, 1893, and Boatman's tailings plant, 1894–96.
† Includes yields from El Dorado, Boatman's Creek, and Walhalla claims.
‡ Includes a yield of 168 oz. from 394 tons from the Alexandra.
§ Includes a yield of 3 oz. from 10 tons from Lady of the Lake.

Painkiller Group.

History.

In the early "seventies" Painkiller Creek and the numerous streams which unite to form Burke Creek were worked for their alluvial gold, and it was probably about the same time that auriferous lodes were discovered in the low hills bounding the lowlands. The first ground prospected was in Painkiller Creek, at the northern end of the area. Ten years later a company known as the Gladstone took up the same ground. A considerable amount of prospecting was done, but nothing worthy of extensive development was found, and the company became defunct in 1886. In 1889 another outcrop was found; and a new company, the Sir Charles Russell, registered 16th October, 1890, took over a claim which included the new find and part of the Gladstone ground. A steam-driven 10-head mill (the old Supreme battery) was erected in 1893 on the left bank of the Waitahu, and connected with the low level by an aerial tram 36 chains in length. Owing to the erratic nature of the ore-bodies the claim did not pay, although the battery gave an extraction of 11 dwt. to the ton. The Dillon Gold-mining Company, registered 12th October, 1891, owned a claim adjoining the Russell on the south, and traversed by the same lode-channel. Prospecting operations, however, were no more successful here than in the adjoining claim. In 1896 the companies were merged into the Dillon Extended, and the low-level adit of the Sir Charles Russell was produced to explore the lode-channel in the Dillon ground. The ore-bodies exposed, however, were too small and erratic to permit of profitable extraction, and in 1899 all work ceased and the claims were abandoned.

In 1906 a Reefton syndicate took up the Ulster, a claim lying farther to the south. The lode in this claim had been discovered many years before by Alexander McCloy, and some work done on it with unsatisfactory results. In 1907 the owners, now known as the Phœnix Syndicate, erected a 5-head battery driven by oil-engine to crush the ore they had developed in their adit. On the 11th March, 1908, the New Ulster Quartz-mining Company was registered, and in subsequent years spent much money in prospecting for a payable ore-body. In this, so far, success has not yet been attained, the work accomplished going to show that the country and ore-lodes of this locality are greatly shaken.

In 1912 another attempt was made to develop the original Gladstone property, now called the Pride of Reefton. Results, however, were unsatisfactory, and work has since ceased.

Workings.

Russell-Dillon Mine.—The first adit in the Sir Charles Russell had its entrance on the south side of the knoll on which Trigonometrical Station E I is situated. There was a crosscut of 50 ft. before the ore, which was up to 2 ft. in thickness and very bunchy and irregular, was struck. This adit followed the lode 190 ft., and from it a winze, following ore of a similar nature, was sunk to a depth of 85 ft. The main low-level adit, 170 ft. below the upper, started from the northern flank of the same knoll. The crosscut to the lode was nearly 700 ft. in length, and the drift was extended along the lode-channel until it attained a length of more than 1,600 ft., of which about 400 ft. was in the Dillon Claim. Connection with the upper drift was made, and also with a winze, which carried ore for the first 50 ft., and which was sunk by the original Dillon Company 7 ft. from their northern boundary. An intermediate level was also driven 96 ft. below the upper adit. These workings, of which no plan is available, proved the lode to have a north-north-west strike, and a steep dip to the westward.

Ulster Mine.—The main adit of the Ulster is about 1,200 ft. long, and of this distance nearly 1,100 ft. is along the ore-channel, which has a strike of about 15° east of north. An adit about 30 ft. above this has also been driven, and is over 300 ft. in length. These workings developed several blocks of ore which, although of fair grade, were too small to recompense the company for the money expended. Throughout the country was wet and shaken.

The lodes and the country throughout this group all show unmistakable signs of having been greatly disturbed, a statement which also applies to the Tertiary strata in the vicinity. The group of lodes occurs just at the edge of the Reefton hills, and must be close to one of the powerful peripheral faults of the Inangahua rift-valley. Hence the writer considers the chance of large ore-bodies ever being found in this locality very remote.

Another lode-series lies about 25 chains to the eastward of the Gladstone Mine, and a cross-section of it is well exposed in the sharp bend of the Waitahu, on the north bank of the river. In the early "eighties" a claim, the Colorado, was pegged out to cover this ground, and some prospecting was done. At the time of the writer's visit some further work was being carried out by Mr. E. Lockington. The lodes here strike about 10° west of north, and dip west, while the country is unaffected by faulting.

The yields from the mines of the Painkiller group of mines will be found in the table on page 133.

Ajax Group.

History.

The Ajax group of metalliferous lodes occurs in the massive block of Palæozoic rocks lying northward of Murray Creek and between the Inangahua and Waitahu rivers. It was in this locality that the earliest discoveries of auriferous quartz in the Reefton district were made. To James Kelly must be ascribed the credit of prospecting the first gold-bearing lode, this being one of the shoots in a claim later, and usually, known as the Golden Treasure. Immediately afterwards Fred Westfield discovered the Victoria shoot, carried by the same lode-series. In October of the same year (1870) Anderson's lode was found, and in November the Ajax shoot.

Two crushing plants for the treatment of the gold-bearing conglomerate of Murray Creek had already been erected, and in 1871 the first quartz was crushed. This consisted of a small parcel of about 80 tons* from Westfield's claim, and the yield of gold was considered very disappointing. Machines more suitable for the reduction of quartz ore were installed by 1872, and highly profitable returns were obtained by the Ajax, Golden Fleece, and Anderson's claims in the following year. Of these the last had a very short life, the shoot being lost at a shallow depth; but the two former, which adjoin, and worked shoots on the same lode-channel, were successful for several years. In 1879 they amalgamated, and the new company was the first to introduce rock-borers and the diamond drill on the Reefton field. This was in 1881, but the enterprise of the directors was ill rewarded, for poor returns were obtained till 1885, when the company went into liquidation.

The companies operating on the first-discovered lode-channel were not nearly so successful, though the Phœnix gave excellent returns during 1874–75, and an adjoining claim (the Inglewood) did well during 1884–86. At the southern end of the lode-series the Golden Treasure has hitherto proved the best shoot, and the excellent results achieved on this claim during 1879–82 led to a revival of mining in this locality.

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* Personal communication from Mr. Thomas Watson, of Crushington.

Since that date, although much money has been expended here, nothing of importance has been discovered. In 1907 the claims at the southern end of the lode-channel were acquired by a Wellington syndicate, which later also purchased those at the northern end, the whole now being owned by the Murray Creek Mines Company.

The Venus lode lies some distance to the westward and parallel with the shoots worked in the Ajax and associated claims. This shoot appears to have been discovered in 1875, and dividends were paid in 1878, but the most successful years of this claim were from 1885 to 1890.

In 1880 an enterprise which had been projected for some time, that of driving a tunnel from Black's Point to the Waitahu River valley, was started. It was intended to tap all the mines of the Ajax Hill at a point many hundreds of feet below any of the then-existing workings. Progress for a long time was rather slow, as the finances of the company did not permit of the use of rock-borers, but by 1888 a distance of 2,880 ft. had been driven for a cost of £8,073, of which the Government had contributed £3,246. At this time most of the mines the project was designed to benefit were defunct or had very poor prospects, and for several years from this date the face made little advance. In 1894 the Venus and the Inangahua Low-level Tunnel companies amalgamated, and next year the property was acquired by Mr. David Ziman, who afterwards transferred it to the Consolidated Goldfields of New Zealand. This corporation installed an air-compressing plant, and commenced driving on the 17th September, 1896. In 1899, at a distance of about 6,000 ft. from the portal, the rising of a shaft to connect with the Ajax workings was begun, a work completed in the following year. From this date the ore-shoots developed along the Ajax lode-channel were vigorously attacked till 1911, when all work ceased. It is a matter for regret that the main adit was not produced a farther distance of 20 chains to Kelly's lode-series, where it would command unworked ground on all the lodes.

Workings.

Inglewood-Phœnix-Victoria Mine.—These claims and the North Star, the ground of which is also included, were originally worked as separate properties, though it is probable that the ore extracted all came from shoots on the same lode-channel. As already stated, the Victoria was one of the first claims in the district to be prospected. Ore was shortly afterwards found in the Inglewood, of which the first crushing was in October, 1872; the Phœnix followed in October, 1874, and the North Star in the succeeding year. It should be noted that these mines, until 1883, when the Inglewood and Phœnix companies erected a 10-head steam-driven battery near the mouth of their low level, had all their ore crushed at the Westland battery in Murray Creek.

The ore-bodies developed by the North Star, Inglewood, and Phœnix companies are undoubtedly on a single lode-channel, and in the upper working this is apparently distinct from that in which the Victoria shoot lies. Of these the Inglewood block seems to have been discovered before the others; but the Phœnix ore-body, opposite on the south side of the creek, was the first to give rich returns. In 1879 the Inglewood Company absorbed the North Star, and the Phœnix ten years later. Operations were not very profitable, and in 1891 the mine was let to tributers, who were very successful for three years. No work seems to have been done from 1897 to 1901, during which latter year the claims, together with the Victoria, were acquired by Mr. P. N. Kingswell, who added a cyanide plant to the mill and took out the Phœnix block for 100 ft. below the low level; the tributers of the old company had already worked the Inglewood block to a like depth. No. 4 adit was extended to command the Victoria ore-body, but the developments in this quarter were not very satisfactory. The property was acquired by a Reefton syndicate in 1908, and in 1910 purchased by the Wellington Mines, a company which merged into the Murray Creek Mines in 1911. This company energetically developed the property with gratifying results, a rich shoot of ore being found in the Victoria Claim. This ore-body, however, was proved to be lying along the western boundary of the claim, and it was only after long negotiations with the Consolidated Goldfields of New Zealand, which held the adjoining ground, that the mining rights over the area to the westward could be acquired.

The upper portion of the Phœnix and Inglewood blocks were exploited by short adits driven on opposite sides of the headwaters of Inglewood Creek. No. 3 Inglewood adit, better known as the United Inglewood and North Star adit, from the fact that it was driven after the amalgamation of those companies, opens to the Waitahu fall. The adit called No. 4 Inglewood on the plan was originally driven by the Phœnix Company, and was afterwards, in 1903, extended by Mr. P. N. Kingswell beneath the old Victoria workings, of which No. 3 adit Victoria is about 40 ft. higher. The other adits by which the Victoria ore-body was developed are respectively 120 ft. and 190 ft. above No. 3, and were driven during 1871–78, the first period of activity of this claim. Some of them were reopened and extended by Knight and party, who held the mine on tribute during 1891–96. This party also drove an adit at a higher level than No. 1 Victoria, exposing a block of ore 2 ft. in thickness. No. 5 adit, or the Inglewood low level, 221 ft. below No. 4 adit, was driven in 1887–88 conjointly by the Phœnix and Inglewood companies, the latter of which had been reconstructed in 1885, and was afterwards, in 1913, extended to the Victoria section by the Murray Creek Mines. The last-mentioned company also sank a shaft, the brace of which is close to the portal of, and practically on the same level as, No. 4 adit. Levels leave this shaft at depths of 220 ft. (connecting with No. 5 adit), 400 ft. (shown as No. 6 on the plan), and 520 ft.

These workings establish that the Inglewood and Phœnix ore-bodies are on the same fissure, which has a strike of about 50° east of north, with a dip to the north-west of about 45°. These shoots are unique in the Reefton district in that their pitch is practically vertical. The Inglewood and Phœnix ore-bodies have each been worked to a vertical depth of about 500 ft. below their outcrops. The former has a length of about 200 ft. with a width of from 1 ft. to 7 ft., with an average of from 3 ft. to 4 ft. A second vein of similar size lies parallel with the Inglewood block, with from 6 ft. to 8 ft. of country between. In the lowest workings on this ore-body—that is, in the intermediate level, 91 ft. below No. 5 adit—the stone is reported to be bunchy and irregular. The Phœnix block has a length of 120 ft., and an average width of 3 ft. Ore is reported to have been left underfoot in the intermediate 100 ft. below No. 5 adit, which constitutes the lowest workings on this shoot. No. 6 Inglewood, however, failed to develop any ore-body in this portion of the mine, the drift being produced along a fissure filled with comminuted greywacke and diabase. It should be noted that a dyke of this igneous rock up to 50 ft. in width forms the usual hanging-wall of these ore-bodies, the parallel lode of the Inglewood section being contained within this rock.

The upper levels of the Victoria disclosed an ore-body over 200 ft. in length and up to 6 ft. in thickness, with a strike of about 18° east of north, a westerly dip of about 55°, and a strong pitch to the north. Nos. 5 and 6 Inglewood levels have proved that the Victoria shoot extends much farther to the northward than was formerly supposed, being at least 450 ft. long. It is probable that the Phœnix, Inglewood, and North Star blocks are fragments displaced from the main shoot by fault-movements. This is supported by the non-appearance of these ore-bodies in No. 6 level, and by the fact that two of them have a vertical pitch, that of the North Star being unknown. The known facts would be explained if an east-north-east-striking normal fault with an angle of dip less than that of the pitch of the shoot had cut off its upper part, and in the displacement so warped the hanging-wall and the ore-bodies contained in it as to produce their altered strike and pitch. Such a fault would be parallel with the known fractures of the Black's Point zone.

Golden Treasure - Band of Hope Mine.—This property also includes the Westland, Golden Hill, and Comstock claims. The lodes of this locality furnished some of the first ore crushed in the Reefton district, the Westland having a crushing in July, 1872, the Band of Hope in October, and the Golden Hill in November of the same year. The yields, however, were not profitable, and mining languished until 1879, when some very good returns were obtained by the Golden Treasure. This company, which seems to have been formed in 1875, owned among other claims that on which James Kelly had made his original discovery of auriferous quartz, and acquired the Band of Hope Claim in 1877. For several years dividends were paid; and in 1883 its battery, built by the Westland Company in 1872 as a Customs plant, was remodelled in the hope of improving the extraction from the refractory antimonial ore yielded by the mine. In 1886 all work ceased, and the property was purchased in 1889 by a syndicate of which Mr. J. B. Beeche acted as manager. The Band of Hope low-level adit was cleaned out, and some fair ore extracted, but operations as a whole were unsuccessful, and work ceased in 1892. In 1893 the mine was let on tribute, and a little desultory mining took place over a period of several years. In 1898 some of the workings were reopened by the Anglo-Continental Company, but nothing of value was discovered; and in 1901 the property had evidently passed to the Consolidated Goldfields, since in that year it is reported that the winding-engine had been removed to the Energetic shaft, while the battery, which was steam-driven and consisted of fifteen stampers, was dismantled. The claim was surrendered in 1906; and later was acquired by the Wellington Mines, which company did a little unsuccessful prospecting before becoming merged in the Murray Creek Mines.

The principal workings consist of adits, for many of which the plans are either incomplete or non-existent. In the Golden Treasure section the low-level adit led to the main workings, and explored the lode-channel for many hundreds of feet. From it a winze, also used as a winding-shaft, led to several intermediate levels, by which the ore-shoot was stoped out. The shaft, the collar of which is 50 ft. above the mouth of the main adit, is 308 ft. deep and 9½ ft. by 4 ft. in the clear. In the Band of Hope section two adits, 190 ft. apart vertically, of which the lower was 170 ft. below the shaft-collar, were driven to the ore-shoot, and connected by a winze from which various intermediates were projected. Another winze was sunk from the lower drift, and a level driven from it at a depth of 150 ft. The plans available do not show these at all adequately.

The workings proved the existence of at least four ore-bodies in the claim. The most northerly (or Westland) block was worked in 1875–76 with poor results. Its width is reported at 4 ft., but there appears to be no record of its length. South of this is what is known as the Golden Treasure north block, which yielded very rich returns, and seems to have been from 2 ft. to 5 ft. wide and over 100 ft. long. The shaft level was extended north in the hope of picking up this and the antimony block, but failed to do so; and, indeed, no ore of any kind was found in this level. Still farther south occurs another block, which was at least 180 ft. long with an average thickness of 5 ft. This is generally known as the antimony block, because of the large quantity of stibnite contained in its ore. It should be noted, however, that this mineral is very prominent in the quartz from all the ore-bodies of this locality. The Golden Treasure main adit opened two parallel ore-bodies about 50 ft. apart, of which the western is the antimony block and the eastern the north block, the two ore-bodies thus overlapping. The Band of Hope block is large, being at least 200 ft. long, with an average width of 6 ft., while it has been followed to a depth of more than 400 ft. Although it contains some rich ore, yet as a whole it is of low grade, yielding no more than 4 dwt. per ton by amalgamation.

Perseverance Mine.—Another ore-body, lying to the westward of the Band of Hope shoot, may also be considered here. This is the Perseverance, on which the first work seems to have been done in 1876. Several small crushings of low-grade ore are recorded from this mine, but in 1880 it appears to have been abandoned. A few years ago the property was taken up by the Consolidated Goldfields. A considerable amount of development was undertaken, and to facilitate this compressed air was piped from the Energetic power plant. These operations proved the existence of an ore-body 200 ft. in length and 3 ft. in thickness, of moderate tenor. The plan shows only the upper adit; a second, driven at a lower level, is of much greater length.

This locality is on the border of an area of intense faulting, and in consequence the ore-bodies are often displaced. In addition to the subsidiary faults of the Murray Creek zone just mentioned, other fractures belonging to the Black's Point zone complicate matters. In the absence of sufficient positive data, such as could have been obtained by an inspection of the underground workings when these were open, the writer can offer no suggestion as to the position of the displaced portions of the north and antimony blocks of the Golden Treasure Claim, but the recovery of these valuable ore-shoots should not be a matter of great difficulty. It may be stated that if the lode-channel along which the shoots of Kelly's lode-series lie maintains its dip, a continuation of Black's Point low-level adit ought to cut it at a point about 500 ft. below the Golden Treasure shaft-bottom after 1,000 ft. of driving.

Golden Fleece - Ajax - Royal Mine.—These properties occur along the same lode-channel, and, although at first controlled by separate companies, were in later years worked together. This series of lodes is named after Richard Shiel, but it was Shiel's mate, George Walshe, who was the actual discoverer of the Ajax shoot. This was in November, 1870; and shortly afterwards the next shoot to the northward, the Golden Fleece, was prospected by Patrick Hunt. In those roadless days incredible difficulties of transport had to be overcome by the Ajax Company before a steam-driven 15-head mill was placed on the ground. It was necessary to barge the boiler and heavy machinery up the Buller and Inangahua rivers as far as Landing Creek, thence by horse-traction along the river-bed to Black's Point, and thence up the hill through the bush by block and tackle. The results obtained justified the hopes of the shareholders, and within a few years £55,000 had been distributed in dividends by the Ajax and Golden Fleece companies. The Golden Fleece was the more successful, and when the companies amalgamated in 1879 the new company was called the Golden Fleece Extended. In 1881 the then managing director, the late Mr. John Trennery, after a visit to the Victorian lode - mines, purchased rock-borers and a diamond drill for the company. Unfortunately, however, the ore-body that had yielded so handsomely was now exhausted, and all efforts to trace its continuation failed; and the claim, after being let on tribute for a number of years, fell into the hands of Mr. Frank Hamilton, from whom it was purchased in 1895 by Mr. Ziman.

To the southward on the same fissure another ore-shoot, usually known as the Royal, was first developed by the Victory Company in 1878. The ground was afterwards owned by the Result and Royal companies, but the ore won was in no case able to pay the expenses of extraction. This mine was also acquired by Mr. Ziman, who transferred it, together with the Golden Fleece and other claims, to the Consolidated Goldfields of New Zealand. This company developed the ore-bodies, built a 20-stamp steam-driven mill at Black's Point, and vigorously exploited the property for many years. The enterprise, however, was not profitable; in 1908 the mine was let on tribute, and all work ceased in 1912.

TABLE SHOWING YIELDS FROM THE AJAX GROUP OF MINES.

Year ended	Phoenix, Inglewood.			Victoria.		Golden Treasure.			Band of Hope.		Golden Fleece, Ajax, Royal.			Venus.			Anderson's, Invincible.		
	Tons.	Oz.	Div.	Tons.	Oz.	Tons.	Oz.	Div.	Tons.	Oz.	Tons.	Oz.	Div.	Tons.	Oz.	Div.	Tons.	Oz.	Div.
Mar. 31—			£					£					£			£			£
1872 ..	27	55	..	..	..	606*	232*	..	31	41	2,603	3,444	..	..	..	..	515	581	..
1873 ..	..	..	..	317	149	..	..	..	..	..	1,483	1,574	..	..	..	..	271	300	..
1874 ..	373	235	..	178	134	..	..	..	390	25	4,047	4,230	..	..	..	..	3,845	3,843	1,525
1875 ..	1,190	768	533	104	104	..	..	..	..	..	3,275	3,262	3,600	..	..	..	2,421	1,142	..
1876 ..	805	1,315	2,800	180	94	..	..	..	..	..	2,411	2,725	..	12	10	..	..	..	..
1877 ..	321	293	..	130	74	..	..	..	144†	13†	3,940	7,684	16,800	..	..	..	..	..	..
1878 ..	..	..	..	..	..	..	..	..	..	..	4,140	6,122	13,200	..	..	..	450	61	..
1879 ..	..	..	..	1,118	724	..	..	..	..	..	720	703	..	2,089	1,205	600	64	38	94
1880 ..	?	327	..	?	342	?	233	..	?‡	13‡	?	837	..	..	..	..	..	..	..
1881 ..	..	..	..	..	..	2,300	994	..	..	..	4,620	5,572	10,800	..	..	..	..	..	..
1882 ..	..	..	..	..	..	1,401	1,476	..	..	..	1,730	1,085	..	..	..	..	..	..	..
1883 ..	..	..	..	..	..	703	636	..	..	..	1,881	2,433	..	..	..	..	..	..	..
1884 ..	?	?	2,400	..	..	..	11	..	..	..	697	477	..	..	..	..	..	..	..
1886 ..	1,355	924	..	..	..	250	235	..	..	..	420	252	..	618	453	..	..	..	..
1887 ..	920	495	300	..	..	..	..	..	..	..	..	..	..	3,603	2,212	2,100	..	..	..
1888 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	224	210	..	..	..	..
1889 ..	620	266	..	..	..	70	36	..	..	..	..	..	..	2,078	1,680	600	..	..	..
1890 ..	2,300	1,329	1,200	..	..	750	357	..	..	..	..	..	..	70	30	..	..	..	..
1891 ..	1,000	463	..	..	..	700	587	900	..	..	22	15	..	840	475	..	..	..	..
1892 ..	450	415	..	..	..	..	..	..	..	..	120	100	..	505	298	..	..	..	..
1893 ..	500	334	..	..	..	39	9	..	..	..	345	496	..	365	204	..	..	..	..
1894 ..	..	..	..	195	114	..	..	..	..	..	939	660	232	309	137	..	..	..	..
1895 ..	250	70	..	326	98	48	10	..	..	..	1,162	450	..	..	..	..	..	..	..
1896 ..	..	..	..	169	155	..	..	..	..	..	1,222	530	..	..	..	..	..	..	..
1897 ..	..	..	..	235	106	315	146	..	..	..	288	166	..	158	129	..	..	..	..
1900 ..	..	..	..	..	..	..	..	..	..	..	..	92	..	..	..	..	..	..	..
Dec. 31—																			
1900 ..	..	..	..	..	..	..	..	..	..	..	1,918	1,947	..	..	..	..	..	..	..
1901 ..	..	..	..	..	..	..	..	..	..	..	14,807	8,880	..	..	..	..	..	..	..
1902 ..	..	..	..	..		..	..	..	..	..	13,614	7,001	..	..	..	..	..	..	..
1903 ..	172	129	..	..	..	..	..	..	..	..	14,133	6,384	..	..	..	..	..	..	..
1904 ..	3,390	1,956	..	..	..	..	..	..	..	..	12,930	6,035	..	..	..	..	..	..	..
1905 ..	1,730	1,655	..	..	..	..	..	..	..	..	13,985	6,541	..	..	..	..	..	..	..
1906 ..	645	929	..	..	..	..	..	..	..	..	6,725	3,141	..	..	..	..	..	..	..
1907 ..	247	146	..	..	..	..	..	..	..	..	11,991	5,161	..	..	..	..	..	..	..
1908 ..	..	..	..	..	..	..	..	..	..	..	1,868	984	..	..	..	..	..	..	..
1909 ..	..	..	..	..	..	..	..	..	..	..	2,813	2,496	..	..	..	..	..	..	..
1910 ..	..	..	..	..	..	..	..	..	..	..	2,796	2,684	..	..	..	..	..	..	..
1911 ..	..	..	..	..	..	..	..	..	..	..	329	380	..	..	..	..	..	..	..

* Golden Hill and Westland. † Includes a yield of 5 oz. from 15 tons from Perseverance. ‡ Perseverance.

Another ore-body lying to the westward of those just mentioned, but probably genetically related to them, may also be here considered. This is the Venus, which seems to have been first prospected in 1875. For the first few years work on this claim was intermittent; but in 1885 a large block was discovered, a new company—the Venus Extended—was formed, the Energetic battery was purchased, and development was vigorously prosecuted. For a few years profitable returns were obtained, but in No. 4 level the ore-body was found to be much broken. In 1893 an amalgamation took place with the Inangahua Low-level Company, it being proposed to work the ore-shoot from that company's adit. About this time, however, the Consolidated Goldfields acquired the mining rights, and all their energies were engaged in the development of the Ajax and Royal ore-shoots; and up to the present no effort has been made to develop the Venus ore-body or discover its relations.

Shiel's lode-series has been opened up very extensively. A shaft 6½ ft. by 4 ft. in the clear, the Golden Fleece or Ajax shaft, ultimately attained a depth of more than 700 ft., and from it five levels* were driven north and south to open up the shoots. The Royal Company or its forerunners also drove four adits to the blocks of ore lying in the southern portion of the fissure. The deeper levels were developed by a vertical shaft, of which the brace was 495 ft. above the Inangahua low-level adit, which joined it at No. 10 level. This shaft attained a depth of 500 ft. below the adit to No. 14 level, from which an incline shaft was sunk 115 ft. to No. 15, the lowest level in the mine.

These lower workings proved the existence of two ore-shoots, known as the north and south blocks. These were directly connected with the ore-bodies worked respectively by the Ajax and Royal companies. In the upper levels a third and much more profitable ore-body, lying farther to the north, was worked with great profit by the Golden Fleece Company. This was followed down to No. 5 level, where the lode became broken up, and, according to H. A. Gordon,† was displaced by a fault north of which it could not be traced. It is probable that three rather ill-defined ore-shoots were worked in the upper levels, and of these the northern was cut off by a fault of which the angle of dip is slightly steeper than the pitch of the shoots. It is certain that in the upper levels a length of more than 1,000 ft. of lode-channel was ore-bearing, a length which in the workings below No. 6 level was reduced to about 700 ft. The disturbance of the north block in No. 15 level may be ascribed to the same fracture, which at this depth reaches the middle or Ajax shoot of the upper workings or the north shoot of the lower for the first time. The northern ends of Nos. 12, 13, and 14 levels turn rather abruptly to the eastward, following in each case a pronounced fissure. The fault probably belongs to the Black's Point zone, and has an east-north-east strike and a northward dip. According to Gordon the shoot of the Golden Fleece was faulted to the westward, but if the above-mentioned suppositions are correct and the fault has no lateral shift the lost portion of the lode may be expected to lie to the eastward.

Venus Mine.—The Venus ore-body was attacked by adits, of which the plans available are by no means complete. Four adits were driven, No. 2 being 168 ft. below No. 1, and No. 3 175 ft. below No. 2. The ore from No. 1 adit was treated at the Golden Fleece (or Ajax) mill; but in 1885, the year in which the lode was struck in No. 2 adit, the company purchased the Energetic battery and erected an aerial tramway to connect it with their underground workings.

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* No. 6 level was driven by the Consolidated Goldfields in 1898, and the shaft was deepened to it in 1907, many years after the extraction of the ore in the level.

† Mines Rep., C.–3, 1896, p. 96.

The ore-body in the two upper adits proved to be from 300 ft. to 350 ft. in length, with an average thickness of 2 ft. The length was less in No. 3, and in No. 4 the reef was so broken up as to be unprofitable. It is evident that the Venus shoot was cut off by a fault, and, as the main faults of this locality are undoubtedly those of the Black's Point zone, east-north-east faulting is indicated. The upper portion of the Royal ore-shoot, where faulting is undoubtedly present, lies exactly in the line that such a fault would take, and it is suggested that the Venus ore-body is actually part of the Royal shoot displaced to the westward. In the low-level adit "good reefing"—that is, crushed—country made its appearance 50 chains from daylight, at least 10 chains before the lode country of the Venus was to be expected, and this crushed country continued nearly to the sharp bend in the adit leading to the Golden Fleece shaft. At the time of the writer's visit the low level was closed, so that the orientation of the movement-planes in this crushed zone could not be ascertained; and since no attempt was ever made to prospect for the Venus ore-body from this point, nothing can be learned from the plans concerning this matter. It is suggested that the crushed rock, penetrated for over 20 chains by the adit, was the fracture-filling of the fault that displaced the Venus ore-body. The fault, to explain the above facts, must have an east-north-east strike with a northward dip of about 75°. It should be stated that the outcrops in both the upper and lower valley of Murray Creek are chaotic, and indicate faulting the direction of which cannot be determined precisely.

Anderson's-Invincible Mine.—This property was one of the first to attain prominence in the Reefton district, paying, within a year of its beginning crushing, not only the cost of its battery, but also handsome dividends. As already stated, ore was discovered in this locality by James Anderson in November, 1870, while Robert Craig was the prospector of the Invincible. A 15-head battery driven by water drawn from the Inangahua was erected at Black's Point, and crushing commenced in December, 1872, in the case of Anderson's, and in January of next year in that of the Invincible. Unfortunately the ore-body was quickly worked out, and, all attempts to trace it in depth having failed, the company collapsed in 1876. Two years later another attempt to develop the claim was made; and till 1884 desultory prospecting proceeded, especially toward the northern end of the lode-channel in Anderson Creek, where a company named the Brutus prospected for some time without result. In the late "nineties" the Consolidated Goldfields projected a drive northward from the low level for nearly 20 chains, but failed to find any trace of lode-material. Again, a few years ago Willis and party commenced an adit from the road-level to explore the ground at a still greater depth. This undertaking was later taken over by the Consolidated Goldfields, and the adit extended to the required length. Some lode-tracks containing broken quartz were cut and explored, but nothing of value was discovered.

The old workings of Anderson's and the Invincible claims consist of three adits, which explored an ore-body 300 ft. in length with an average thickness of perhaps 3 ft. According to information supplied by miners who worked in the claim, the lode was decidedly broken, and terminated against a slickensided wall. The dip was to the eastward at a steep angle, but the lode flattened and actually turned upward near the point where the ore-shoot was cut off. It is evident that this ore-body has been shattered and displaced by a fault; and since the powerful Black's Point fault is only a few chains away it may be assumed that one of its subsidiary fractures is here concerned. The strike of the ore-body is about 42° east of north, while that of the Golden Fleece lode is about 28° east of north, and this difference in orientation may be ascribed to the influence of the fault. In driving the low level (Golden Fleece) a gold-bearing leader was cut about 200 ft. from the portal, and this may well be the southern continuation of Anderson's lode-channel, and with it must also be considered the lode-traces explored from Willis's adit. Perhaps the tracks in the Mars Claim on the south bank of the Inangahua, prospected in 1894, may also belong here.

Although the dip of the ore-body is south-eastward, all the ore-shoots in its vicinity dip westward, and in all probability it is a fragment of a westerly dipping shoot. The close proximity of the broad belt of crushed country forming the Black's Point fault, and the practical certainty that both fault and ore-shoot dip westward, make the chances of discovery of a payable ore-body remote.

Crushington Group.

History.

The history of this group of lodes dates from late in 1870, when Adam Smith found ore in a claim that appropriately received the name of Wealth of Nations. Another claim, the Energetic, adjoining it on the north, was soon afterwards found, and by March, 1872, had begun crushing at a 10-head water-driven mill.* The Wealth of Nations' first crushing was in January 1873. Both claims were highly remunerative, and although their ore was of a decidedly lower grade than that of most of the other mines at work at this period they quickly paid the cost of their batteries, and for several years distributed handsome dividends. Their success stimulated prospecting in the numerous claims in the vicinity, of which the most noteworthy were the Dauntless, Macedonian, Independent, Heather Bell, Vulcan, Golden Ledge, and Keep-it-Dark. The Dauntless (later the Undaunted) struggled on for many years; the Macedonian was absorbed by the Energetic; and a like fate befell the Independent, Vulcan, and Heather Bell, which were merged with the Wealth of Nations in 1879. The Keep-it-Dark, which now holds the Golden Ledge ground, was very successful. This company, registered on the 2nd March, 1874, held a claim that had been prospected without success at an even earlier date. The first crushing was in 1875, and the claim has been one of the most consistently profitable in the Reefton district. An adjoining claim, the Hercules, started crushing at about the same time, but although it was worked until 1899 its career was inglorious. Other claims in this locality—the No. 2 South Keep-it-Dark, the South Wealth of Nations, and the Pandora—were also unsuccessful, and require no further mention here.

The northern claims of this group exhausted the fine ore-bodies of their upper levels in the early "eighties," and were unable to pick them up in depth. The Energetic was let on tribute for a number of years, but was finally abandoned. The Wealth of Nations had from the very beginning stacked its tailings; and from the retreatment of these obtained sufficient gold to maintain, with the help of occasional calls, its prospecting operations for sixteen years, when at last the downward extension of its shoots was found. Later this claim, together with the Energetic, passed into the possession of the Consolidated Goldfields of New Zealand, and is still being worked with great profit.† At present the deepest workings in the Dominion are in the Energetic section of this mine, where the Wealth of Nations shoots are being attacked at a depth of 1,900 ft. from the surface and 730 ft. below sea-level.

Workings.

Energetic - Wealth of Nations Mine.—The writer was unable to obtain any plans of the old Energetic workings, or of those undertaken by the tributers who from

* This mill was later increased to 25-head, and steam superseded the inadequate water-supply of Murray Creek.

† In the table on p. 157 no dividends are credited to the Wealth of Nations for the reason that the Consolidated Goldfields holds a large interest in the Progress Mines, profits from which have paid part of the dividends of the parent company.

[*Photo by W. Sherlock.*

PLATE VIII.—VIEW OF WEALTH OF NATIONS OLD PLANT, SHOWING BATTERY OVERSHOT WHEEL (50 FT. DIAM.) ON THE LEFT, AND WINDING-WHEEL (30 FT. DIAM.) ON THE RIGHT.

Face p. 152.]

1887 to 1893 successfully worked the claim under the style of the Energy Company. All that is known is that several adits were driven, and a shaft 9 ft. by 4 ft. in the clear was sunk to a depth of 360 ft. The ore-bodies were large, but about 300 ft. below the outcrop the lode became broken up and could not be traced downward. The Dauntless Company immediately to the north did a great deal of surface prospecting, and drove several adits on small ore-bodies without developing anything of a payable nature.

In the Wealth of Nations section of this property four adits were driven in the early days in addition to the Independent low level and the Vulcan "tunnel." Ore was carried down to a depth of about 300 ft. below the outcrop by these workings, but at this point the lode became broken up and unpayable. The fissure, filled with a mixture of ore and "mullock," was followed downward for over 500 ft. before a commercially valuable block was again found. The downward continuation of the ore-shoot was discovered in 1893, and the mine was purchased by Mr. Ziman in 1895. The Consolidated Goldfields, to which the property was later transferred, sank the incline shaft started by the old company to a depth of 800 ft. below the main adit. The old Energetic shaft, reopened and enlarged in 1901, has since attained a depth of 2,300 ft., and from it all the ore produced by the mine is now drawn.

From an examination of the plan of the workings below the main adit it is clear that three ore-shoots occur in this portion of the property, and a plan of No. 7 level indicates their relations to each other.* They have a nearly vertical dip and strong northerly pitch. The east shoot was discovered in 1904 by a diamond-drill bore from No. 7 level, and has been traced upward to No. 6 level, where it is broken up and shattered, evidently by the same fault-belt that caused the 550 ft. blank between the ore-bodies of the old adit workings and those of the lower levels. These latter first appeared in the 350 ft. level of the incline shaft, where, it may be stated, the blocks of ore occurred in most erratic attitudes, some even lying flat. The writer's data are too scanty to enable the course and nature of the fault to be definitely stated, but the facts are most readily explained on the supposition that it strikes east-north-east and has a downthrow to the north.

The most reasonable explanation of the disappearance of the Energetic ore-bodies in depth is that they were displaced by a fault, a suggestion supported by the fact that the lowest block worked was horizontally disposed. In 1913 a prospecting crosscut from No. 9 level intercepted an ore-body westward of any hitherto worked. This was later also cut in Nos. 7 and 8 levels, and is almost certainly the displaced portion of the Energetic shoot. If such be the case the movement was probably caused by an east-and-west fracture with a steep northerly dip. Perhaps also the shattering of the most northerly of the Wealth of Nations shoots noted in No. 11 level is due to this fault, which will then be analogous with that described in the preceding paragraph, which likewise shifted the Wealth of Nations shoots to the westward.

Keep-it-Dark Mine.—Ore from this mine was first crushed in 1875 at the 15-head mill built in the preceding year by the Inangahua Public Crushing Company. This plant was later acquired by the Keep-it-Dark Company, which increased its capacity to 20 heads, and in 1899 added a cyanide plant. Before this date the whole of the tailings from this mine were discharged into the Inangahua without retreatment. Since the erection of cyanide and concentration plants at this mine from 60 to 70 per cent. of the gold has been saved by the ordinary process of amalgamation. The battery practice was certainly no better in the old days than at present; and it may be assumed that from this mine alone till 1896, when the tailings were stacked for retreatment, something in the neighbourhood of £120,000 of recoverable gold was

* See p. 112.

lost by reason of the company neglecting to stack the tailings from its mill. In spite of this waste the mine has been conspicuously successful, few years being without dividends until 1909, since which date none has been paid. "After thirty-seven years of profitable work, and the payment of 184 dividends amounting to £158,666 13s. 4d. on a paid-up capital of £8,708 6s. 8d., the shareholders of the company (the Keep-it-Dark Quartz-mining Company, Limited) agreed to go into liquidation and reconstruct the company under the name of the Keep-it-Dark Mines (Limited)." * The new company was registered on the 8th February, 1911, and since that date has actively worked its claim, but so far without the reward of dividends.

Two lode-channels traverse the claim, and until 1898 only the ore-bodies on the eastern were worked. These outcropped on the hillside at a height of 180 ft. above the collar of the shaft, and were at first worked by means of adits by the Keep-it-Dark and Golden Ledge companies. The workings on this fissure are very imperfectly shown on the plans, but were reached by levels projected from the shaft at depths of 152 ft., 312 ft., and 473 ft. At the northern end of the No. 3 level, at a distance of 522 ft. from the shaft, a blind or "monkey" shaft was sunk, which ultimately attained a depth of 491 ft. below No. 3 level. Four levels were driven from it to develop the ore-bodies at depths of 120 ft., 245 ft., 370 ft., and 480 ft. below the brace. Since 1898, when the western lode was found, the energies of the company have been directed to its exploitation. The existing levels from the main shaft were driven to it, the shaft itself deepened, and other levels constructed—No. 4 at 624 ft., No. 5 at 773 ft., No. 6 at 923 ft., No. 7 at 1,024 ft., No. 8 at 1,145 ft., and No. 9 at 1,345 ft. respectively from the shaft-collar.

Although the workings described are quite extensive, most of the levels are now closed, and the writer could learn little concerning the structure of the ore-bodies. The eastern shoot, from which the ore that yielded the earlier dividends was taken, was probably shattered by faulting. Thus the Wardens and Inspectors of Mines mention the occurrence of numerous blocks, that known as the north block containing the richest ore. Below No. 3 level this shoot was difficult to trace, disconnected blocks—that is, fragments of the shoot—being found in unexpected positions, and lying in all sorts of attitudes, and with all sorts of orientations. The search for these blocks was conducted in a haphazard manner, and was very costly. In 1898 the western shoot was struck; and no more work was done in the direction of proving the eastern shoot until 1909, when a drive was extended from No. 7 of the main shaft northward beneath the workings of the blind shaft, with which connection was made. A small amount of prospecting was carried out, but nothing of value was disclosed. The north block was evidently of considerable size, and there are records of thickness ranging from 8 ft. to 29 ft., and one report speaks of a block 350 ft. in length and 8 ft. wide.

The western shoot was fairly regular in the upper levels, being in two blocks in No. 2 level, respectively 185 ft. and 50 ft. long, and averaging 9 ft. in width; in No. 3 these dimensions were 220 ft. and 40 ft., with a width of 7 ft.; in No. 4 "mullock intrusions" were numerous; and in No. 5 the main ore-body was found to be out of its expected position; No. 6 level furnished much ore, two blocks, the one 270 ft. by 6 ft. and the other 180 ft. by 5 ft., being developed; in No. 7 the shoot was much disturbed, and a like condition obtains in Nos. 8 and 9 levels. In nearly every level large disconnected ore-bodies with an east-and-west strike and variable dips have been found, but the main blocks strike west of north, have a general westerly dip, and northerly pitch.

* Bishop, T. O.: Mines Rep., 1912, C.–2, p. 46.

It is evident that the western shoot has been affected by powerful fault-movements. The frequency of the east-and-west-striking blocks, were it not for their individual isolation, would suggest the presence of an ore-shoot with that original orientation. The more probable explanation, however, is that they are fragments of a north-and-south-striking ore-shoot that have been turned at right angles to their normal direction by an east-and-west fault. Possibly the same fault, but more probably one parallel to it, is responsible for the shattering of the eastern shoot, but the data available are so meagre that only a tentative opinion can be formed as to the structure of the ore-bodies. It is suggested that both shoots are contained in a relatively undisturbed belt of country, bounded on the north and on the south by faults with an easterly trend probably belonging to the Black's Point zone.

Hercules - No. 2 South Keep-it-Dark Mine.—The northern claim of this group was first worked in 1875 by a company named the Hercules, but two years later the ground seems to have belonged to the Nil Desperandum Company. This concern maintained a precarious existence until 1889, when it was acquired by a new company, also known as the Hercules, which struggled on until 1899. The southern claim, or group of claims—for three companies, the No. 2 South Keep-it-Dark, South Wealth of Nations, and Pandora, contributed to the sinking of the shaft—was even less profitable. The No. 2 South Keep-it-Dark, formed in 1882, showed most vitality. The other two were registered in 1886, the Pandora commencing operations on an outcrop exposed in cutting the Keep-it-Dark water-race. The shaft was started in the year following, but as nothing was discovered the Pandora and South Wealth of Nations ceased work in 1890, and were purchased by the No. 2 South Keep-it-Dark in the beginning of 1894. This company deepened the shaft to 472 ft., but after several years of unsuccessful effort ceased operations in 1899. The ore from these claims was crushed either at the Wealth of Nations or the Keep-it-Dark batteries, and both claims now belong to the latter company.

The plans of the workings of this group of claims are by no means complete. The Hercules shaft was sunk 300 ft. from the mouth of No. 3 adit, and reached within 46 ft. of sea-level at a depth of 735 ft. Six levels were driven from the shaft, Nos. 4 to 9, at depths of 100 ft. (?), 200 ft. (?), 290 ft., 414 ft., 564 ft., and 713 ft. respectively. The No. 2 South Keep-it-Dark main workings are approached by a shaft 472 ft. in depth, with levels projected from it at 178 ft., 278 ft., and 450 ft. respectively. No. 2 level of this shaft was connected with No. 7 of the Hercules by a winze 260 ft. deep.

The workings are all on the same lode-channel, the continuation of which northward probably carries the eastern shoot of the Keep-it-Dark. Along the southern portion of this channel there have evidently been post-mineral movements, as the known ore-bodies, although all on a well-defined fissure, are crushed and discontinuous.

The two most important ore-bodies developed were both traced downward as far as No. 8 level, Hercules. The southerly block was first found in the 278 ft. level of the No. 2 South Keep-it-Dark near the northerly boundary of that claim, and the pitch of the shoot soon carried it into the adjoining Hercules Claim. The writer has no reliable information regarding the length of this ore-body, and its thickness does not seem to have exceeded 5 ft. The second block was some 600 ft. to the northward, but, as an ore-body, was even less satisfactory than that just mentioned. Boulders and fragments of high-grade ore were found at numerous points between the two blocks, as well as along the fissure hundreds of feet south of the Pandora shaft. The No. 2 South Keep-it-Dark projected a crosscut westward from No. 3 level in search of the lode-channel on which is developed the western shoot of the Keep-it-Dark. This reached a point more than 500 ft. from the level, but although several tracks were cut nothing of value was discovered.

A table showing the yields from the Crushington group of mines will be found on page 157.

Globe-Progress Group.

History.

The great tabular mass of quartz of the Globe and Progress claims was known for many years before it was worked. What is known as the dam block was uncovered by Robert Wolf and party, who in the late "seventies" constructed a dam in Oriental Creek in connection with the water-race to their alluvial claim near Soldier's Township. The quartz was considered to be barren, or at least unpayable, an opinion strengthened by the very poor returns obtained by the Union Company of 1879, when 600 tons of ore yielded only 64 oz. of gold. This claim was prospected by the brothers Adams in 1876; in 1878 a 10-head mill was erected in Devil Creek, and this was sold to the Oriental Company in 1881. The Oriental Company had also been formed in 1876, but, although it energetically prospected its holding and discovered several large ore-bodies, its operations were not successful from a monetary point of view, and in 1888 the claim and plant were sold. Gold-bearing stone was found on the Globe Claim in 1882, and a company to work it was registered on the 15th April, 1882. Large ore-bodies were uncovered, and a water-driven 20-head mill was erected on the left bank of the Inangahua. Connection with the mine was by means of an aerial tramway, and later haulage from the shaft was done by a wire rope led along the tramway-trestles from the power-station at the mill, 96 chains away. The ore for several years proved unpayable, and the company was on the verge of liquidation when, in September, 1886, a new outcrop was discovered on the claim 1,000 ft. to the westward of that being worked, and close to the Oriental boundary, across which the vein was afterwards traced on the surface. This was the turning-point in the history of the company, which worked the claim with steady success until bought out by Mr. D. Ziman in 1896.

A few weeks before the new strike of ore in the Globe ground the company owning the adjoining Oriental Claim went into voluntary liquidation, and the property was sold to Mr. Gerald Perotti for the small sum of £320. That gentleman endeavoured to raise capital to prospect the claim, but met with poor success until the new find of the Globe was reported, after which he had no difficulty in floating a company named the Progress (registered November, 1886). Profitable ore was soon found, and henceforth until the mine was purchased by Mr. Ziman the company was successful.

The Globe and Progress mines were taken over by the Consolidated Goldfields and, together with other areas in the neighbourhood, were floated into a subsidiary company under the style of the Progress Mines (Limited). Great sums were expended in developing the property and providing means of transport and a treatment plant. Thus a new shaft that is now 1,416 ft. in depth was started; a 40-head battery, afterwards enlarged to 65 heads, built, and water-power brought to it from the Inangahua; a roasting-furnace and cyanide plant erected; and a new aerial tramway connecting mill and mine constructed. The battery began crushing in May, 1898, and, except during the labour strike of 1912, has been in continuous operation since. For many years the yield obtained was very profitable, enabling fair dividends to be paid even on the watered stock of the company. Below No. 8 level the lode entered a belt of country shaken by faults, and gradually became more and more disturbed until in No. 11 level it was abruptly terminated. All efforts to trace the continuation beyond this fracture have hitherto failed, and, although the mine contains ore reserves that will enable it to work for years, its future depends on the location of the lode beyond the fault-zone.

[*Photo by W. Sherlock.*

PLATE IX.—VIEW OF PROGRESS MILL, SHOWING ROASTING AND REVERBERATORY FURNACES AND CYANIDE PLANT.

Face p. 156.]

TABLE SHOWING YIELDS FROM THE CRUSHINGTON AND GLOBE-PROGRESS GROUPS OF MINES.

Year ended	Energetic and Energy.			Wealth of Nations and Independent.			Keep-it-Dark and Golden Ledge.			Hercules and Nil Desperandum.			No. 2 South Keep-it-Dark and Pandora.			Globe and Progress.		
	Tons.	Oz.	Div.	Tons.	Oz.	Div.	Tons.	Oz.	Div.	Tons.	Oz.	Div.	Tons.	Oz.	Div.	Tons.	Oz.	Div.
Mar. 31—			£			£			£			£			£			£
1872 ..	10	42	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1873 ..	297	108	..	330	253	..	..	..	..	..	..	..	..	..	..	..	..	..
1874 ..	1,636	1,028	..	4,654	3,047	..	..	..	..	..	..	..	..	..	..	..	..	..
1875 ..	4,453	2,902	..	5,585	4,067	5,561	..	..	..	..	..	..	..	..	..	..	..	..
1876 ..	7,850	5,510	9,000	8,156	5,564	10,075	4,731	1,674	333	595	770	1,400	..	..	..	..	..	..
1877 ..	8,223	4,480	3,900	9,376	6,314	8,125	4,886	1,417	..	64	20	..	..	..	..	..	..	..
1878 ..	11,600	5,952	6,300	9,589	5,011	7,800	8,141	5,123	6,583	230	127	..	..	..	..	..	..	..
1879 ..	5,938	3,656	..	3,105	2,136	..	3,614	1,911	1,000	1,803	943	..	..	..	..	600*	64*	..
1880 ..	?	3,042	..	?	1,908	..	?	4,058	..	?	131	..	..	..	..	580†	295†	..
1881 ..	8,423	3,312	1,800	2,378	804	..	5,115	1,989	2,000	192	74	..	..	..	..	..	..	..
1882 ..	3,277	1,185	..	765	334	..	1,450	453	500	1,078	548	144	..	..	..	..	..	..
1883 ..	..	..	..	440	402	..	9,194	7,174	17,000	..	..	..	..	..	..	..	..	..
1884 ..	280	70	..	80	122	..	7,373	5,510	12,000	..	..	..	..	..	..	6,580	2,058	..
1885 ..	..	..	..	?	?	..	?	?	14,000	..	..	..	..	..	..	?	?	..
1886 ..	..	..	..	340	201	..	10,075	6,158	14,500	..	..	..	..	..	..	850	171	..
1887 ..	..	..	..	100	291	..	9,072	5,254	13,000	..	..	..	..	..	..	730	808	1,200
1888 ..	..	..	..	..	207	..	7,517	2,379	3,000	922	270	..	370	372	..	9,780	6,827	12,450
1889 ..	..	..	..	..	209	..	8,315	5,059	10,000	1,408	624	288	844	704	400	8,920	4,612	1,800
1890 ..	2,071	800	..	85	233	..	5,757	2,538	6,500	329	310	..	420	356	600	13,274	5,690	4,950
1891 ..	777	377	..	1,997	695	..	5,081	1,769	1,000	262	211	300	1,347	1,190	1,800	19,907	11,048	16,900
1892 ..	780	460	..	609	346	..	2,738	906	500	238	145	..	4,295	2,482	4,200	13,730	6,437	7,200
1893 ..	583	560	..	721	317	..	1,550	470	..	107	40	..	2,406	1,664	2,200	18,412	8,651	8,400
1894 ..	525	170	..	3,875	1,156	..	450	130	..	1,092	785	1,500	105	71	..	15,730	7,612	4,800
1895 ..	30	8	..	3,379	954	812	936	334	..	2,610	1,215	1,200	50	12	..	11,595	4,992	4,200
1896 ..	..	..	..	3,347	1,190	1,625	4,169	2,389	5,250	1,646	823	1,200	..	..	..	12,390	5,416	6,900
1897 ..	..	..	..	1,095	260	..	2,550	2,264	3,000	796	306	..	..	..	..	4,830	2,306	..
1898 ..	..	..	..	932	187	..	3,282	1,057	..	..	13	..	..	..	..	3,644	1,358	..
1899 ..	..	..	..	..	..	..	2,184	911	..	..	..	..	12	4	..	37,500	16,835	..
1900 ..	..	..	..	2,702	1,003	..	9,100	3,784	1,000	..	..	..	..	..	..	46,001	22,378	41,250
Dec. 31—																		
1900 ..	..	..	..	1,979	711	..	9,022	3,312	5,000	..	..	..	..	..	..	40,564	15,537	27,500
1901 ..	..	..	..	12,015	5,222	..	12,442	4,489	4,000	..	..	..	..	..	..	55,207	23,399	27,500
1902 ..	..	..	..	11,566	5,544	..	11,405	3,801	1,000	..	..	..	..	..	..	55,976	26,437	27,500
1903 ..	..	..	..	12,385	4,820	..	12,568	5,282	8,750	..	..	..	..	..	..	57,114	27,346	34,375
1904 ..	..	..	..	12,478	5,153	..	12,300	5,515	6,750	..	..	..	..	..	..	59,908	27,335	34,375
1905 ..	..	..	..	11,970	4,702	..	12,730	5,021	6,750	..	..	..	..	..	..	60,000	24,898	34,375
1906 ..	..	..	..	12,676	5,798	..	13,300	4,825	9,000	..	..	..	..	..	..	59,100	23,477	34,375
1907 ..	..	..	..	13,690	6,450	..	13,441	4,144	3,000	..	..	..	..	..	..	55,305	22,825	34,375
1908 ..	..	..	..	13,479	6,821	..	13,170	3,776	1,000	..	..	..	..	..	..	48,500	15,487	..
1909 ..	..	..	..	15,577	7,223	..	11,163	3,065	..	..	..	..	..	..	..	35,414	14,100	13,750
1910 ..	..	..	..	21,363	9,434	..	3,273	918	..	..	..	..	..	..	..	50,207	18,817	..
1911 ..	..	..	..	24,968	12,486	..	7,212	2,146	..	..	..	..	..	..	..	41,596	11,125	..
1912 ..	..	..	..	10,936	4,692	..	10,180	3,370	..	..	..	..	..	..	..	8,770	3,511	..
1913 ..	..	..	..	23,661	9,489	..	7,245	2,439	..	..	..	..	..	..	..	34,996	9,689	..
1914 ..	..	..	..	25,470	9,980	..	13,627	4,744	..	..	..	..	..	..	..	33,150	10,495	..

* Union. † Oriental.

In addition to the claims just mentioned others in the vicinity received attention, the most important being the Argosy, Empress, and General Gordon. None of these claims was successful, although prospecting continued for several years. The Souvenir vein, discovered by Messrs. G. G. Wise and R. Shiel in 1879, also deserves mention in this place.

Northward of the Progress group of claims a number of auriferous veins outcrop in Auld Creek. These seem to have been first prospected by Theodor Ranft and William Falla in the early "seventies," but nothing of value was then discovered. They again attracted attention in 1882, mainly on account of their antimony-content, but, although several of the claims were during this period found to contain auriferous lodes, the prospects were not considered sufficiently encouraging for the erection of a treatment plant. In 1908 another attempt was made to explore the lodes in this locality. This met with partial success, but the owners were hampered by litigation and by the regulations restricting mining in the water-conservation reserve from which Reefton draws its domestic supply.

Workings.

The main workings of the original Globe Company were reached from a shaft 825 ft. in depth, which was sunk to develop the block found in 1886, and is now known as the A shaft. The earliest workings were more to the eastward, near the terminal of the old aerial tram before the deviation to the A shaft was constructed, and in this neighbourhood an incline shaft known as the Ballarat (or C) shaft was sunk. All the workings below No. 6 level are reached by way of the new (or B) shaft sunk by the Progress Mines. The top of the A shaft is 1,691 ft. above sea-level, and the chambers of the various levels down to No. 6 are at points 125 ft.(?), 250 ft. (?), 367 ft., 490 ft., 615 ft., and 816 ft. respectively below the shaft-collar. Of the levels from the B shaft, No. 4 and No. 6 connect also with those from the A shaft, while levels Nos. 7 to 11 are respectively 916 ft., 1,016 ft., 1,116 ft., 1,266 ft., and 1,416 ft. below the collar, which is 1,690 ft. above sea-level. The old Progress workings are approached by two adits from Devil Creek. From the lower, which is about 44 ft. above No. 4 shaft level, an underground vertical shaft was sunk to a depth of 450 ft., and from it three levels were opened. Winding from this shaft was at first by means of compressed air, but this was replaced in 1894 by steam.

In the upper workings of this mine at least eight large bodies of ore were stoped. In the old Progress Claim, from west to east, these were Smith's, Adams', and the dam blocks; in the Globe, the west, middle, east, and Union (two) blocks; but in the lower workings these lost their distinctiveness to a great extent. The Progress blocks were grouped under that name and worked down to No. 10 level, below which they could not be traced. The three western blocks of the Globe united about No. 6 level to form one great ore-body, which maintained its integrity to No. 8 level, below which it was broken up by faulting. The other two blocks worked by the original Union Company united in depth into what is usually known as the Union (or east) block (not to be confounded with the east block of the old Globe). Below No. 8 this ore-body also lost its identity, being broken up by faults into many fragments. The result of the earth-movements has been that the three levels below No. 8 have developed ore-bodies lying in all sorts of attitudes and with many orientations. In No. 9 level, from which a very large tonnage of high-grade ore has been mined, the structure of the ore-bodies has been described as anticlinal. The writer has had no opportunity of studying the facts of occurrence, but on general grounds is inclined to doubt the existence of such a structure, the probable explanation being that two fragments of the main shoot have been shifted by earth-movements into positions that simulate an anticlinal arch. No. 9 proved a very profitable level, while a contrary statement applies to No. 10. The chief ore-body of No. 11 level is known as the Pioneer block, and consists of a large flat-lying mass of quartz elongated meridionally and with a slight pitch southward. It varies in thickness, averaging perhaps 20 ft. At its south end, where it is terminated by an east-and-west fault, it is about 200 ft. wide, but this gradually decreases northward until in No. 10 level, where it has recently been discovered, it is not much more than 100 ft. wide.

The Globe-Progress lode is decidedly the largest so far developed in the Reefton district. In the upper workings it has been traced for at least 30 chains, although it is not continuous for this whole distance, but, as already stated, is broken up into a number of blocks. Its course here is on the whole a little south of east, but at the eastern end this turns to a little east of south, linking it with the great north-north-east lode-series that traverses the country from Merrijigs to Auld Creek. The large blocks of ore which were worked by the old Progress Company, and of which the downward extension was exploited to No. 10 level, have in general a strike of a few degrees west of north. There is, however, not the slightest doubt but that they owe their present orientation to the powerful north-north-west fault that limits to the westward the ore-bodies hitherto discovered. In depth the strike of the main ore-body gradually changes until it conforms with that of the lode-series or "reef-line" mentioned above. The dip is at first to the southward at about 60°, but changes to the westward as the strike alters in direction. As already stated, the great west fault dislocated the lode at its western end on the surface, but did not affect the main ore-bodies until No. 8 level was reached, at which depth the westward dip brought the lode within the influence of some of the fractures subsidiary to the main fault. Down to this level the dip was fairly regular, and averaged 60°, but below it the ore-bearing zone gradually flattens until at No. 11 level the main ore-bodies are horizontally disposed. The result of this flattening has been greatly to increase the amount of ore commanded by Nos. 9, 10, and 11 levels. It is evident from the flattening of the ore-bearing zone in the lower levels that the earth-block containing the lode has been let down relatively to that on the western side of the fault, a conclusion confirmed by the occurrence of a considerable amount of drag-quartz upward from No. 11 level along the main plane of movement. The zone of moderately disturbed country in which the blocks worked in Nos. 9 to 11 levels occur is traversed not only by faults subsidiary and sub-parallel to the main fracture, but also by dislocations crossing these with angles approaching 90°. The structure here is exceedingly complex and difficult to understand. Since the writer's visit a model of the ore-bodies of the Progress Mine, so far as known, has been made, and this ought greatly to assist the management in the elucidation of the structure. On the surface the belt of disturbed country to the westward of the workings is between 25 chains and 30 chains in width, and it is probably traversed by several pronounced ruptures similar to that against which the ore-bodies terminate. Between these will occur country much less disturbed, where the lode-fragments will probably be large enough to permit of profitable mining. Up to the present the efforts of the company to locate ore-bodies beyond the main fracture have failed. It has, however, been established, from the exploration along the main fracture-plane, that the ore-bodies beyond the fault lie at a level higher than No. 9 level, and it is reasonable to hope that a continuance of the present intelligently directed operations will lead to success. It must be noted that the diamond drill has been extensively used for prospecting in this mine, and, although the results achieved have justified the expenditure incurred, they have certainly not been as successful as might have been expected. The caving nature of the crushed country offers great difficulties to the boring of deep holes without great expense. It may be stated that a vertical drill-hole from No. 11 level reached a depth of over 1,000 ft. without penetrating anything of value.

Of the prospects lying to the south of the Globe-Progress workings, the General Gordon and the Empress are certainly on the same lode. The ore averages 2 ft. in width, and is not of high grade. Again, it is reported that the low-level adit of the General Gordon failed to find ore. These are probably the reasons why this area has been neglected since the early "nineties."

Immediately to the south is the Souvenir Claim, of which the vein lies a little to the westward of the direct line of the General Gordon - Empress lode. The outcrop may be traced on the surface for nearly 100 ft. as a narrow quartz vein carrying much stibnite. In the Reefton district this mineral is so constantly associated with rich ore that the lode is worthy of further development on this account alone.

McKay* in 1882 described an occurrence of antimony-ore in Auld Creek. In the years following a considerable amount of prospecting was done in this locality, and numerous quartz veins were discovered, some of which contained gold to an encouraging extent. Within recent years more favourable results were obtained in the Bonanza Claim, where an ore-body 8 ft. to 9 ft. in width and worth about £1 10s. per ton in gold was found. This block is north of and is very closely connected with the stibnite-bearing lode discovered many years ago by Theodor Ranft.

Maori Gully Group.

This large group of lodes has not, up to the present, been found to include an ore-shoot of commercial value. The claim that has received most attention—the Golden Point—covers the rock-cut terrace-point separating the main branches of Devil Creek. The auriferous lodes traversing the greywacke of this area seem to have been uncovered by the sluicing operations of Newth and party, probably in 1878. A company was registered on the 1st July, 1882, and vigorously prospected the ground. A 10-head battery was erected, and about 1,000 tons of quartz was crushed. Several gold-bearing lodes up to 4 ft. in width, as well as richly auriferous leaders, were explored, but the returns were unremunerative; and in 1885 the property passed into the hands of Mr. G. Perotti, the principal shareholder, who steadily prospected the claim for many years. In 1907–8 trial crushings were made with unsatisfactory results, and in 1911 a shaft was sunk from which a level has been driven and several tracks and leaders intersected. The country of this claim is decidedly faulted, and the blocks of rich ore are small and broken.

At the time of the discovery of the Golden Point lodes the ground to the southward was also prospected, and numerous quartz outcrops were laid bare. Of these the Morning Star vein, found by William Harvey, was promising but did not open up well, the gold-bearing leader, which strikes at right angles to the general trend of the lodes, being very erratic. Another claim in this locality on which a good deal of money was spent was the Koh-i-noor. In 1912 Bierworth and party worked the old Morning Star under the name of the New Discovery, and erected a small battery on the ground. A crushing of 20 tons, however, was hopelessly unpayable, and the claim was abandoned.

North of the Golden Point, in the block of shattered greywacke drained by Darkie and Soldier creeks, several outcrops have from time to time received attention.

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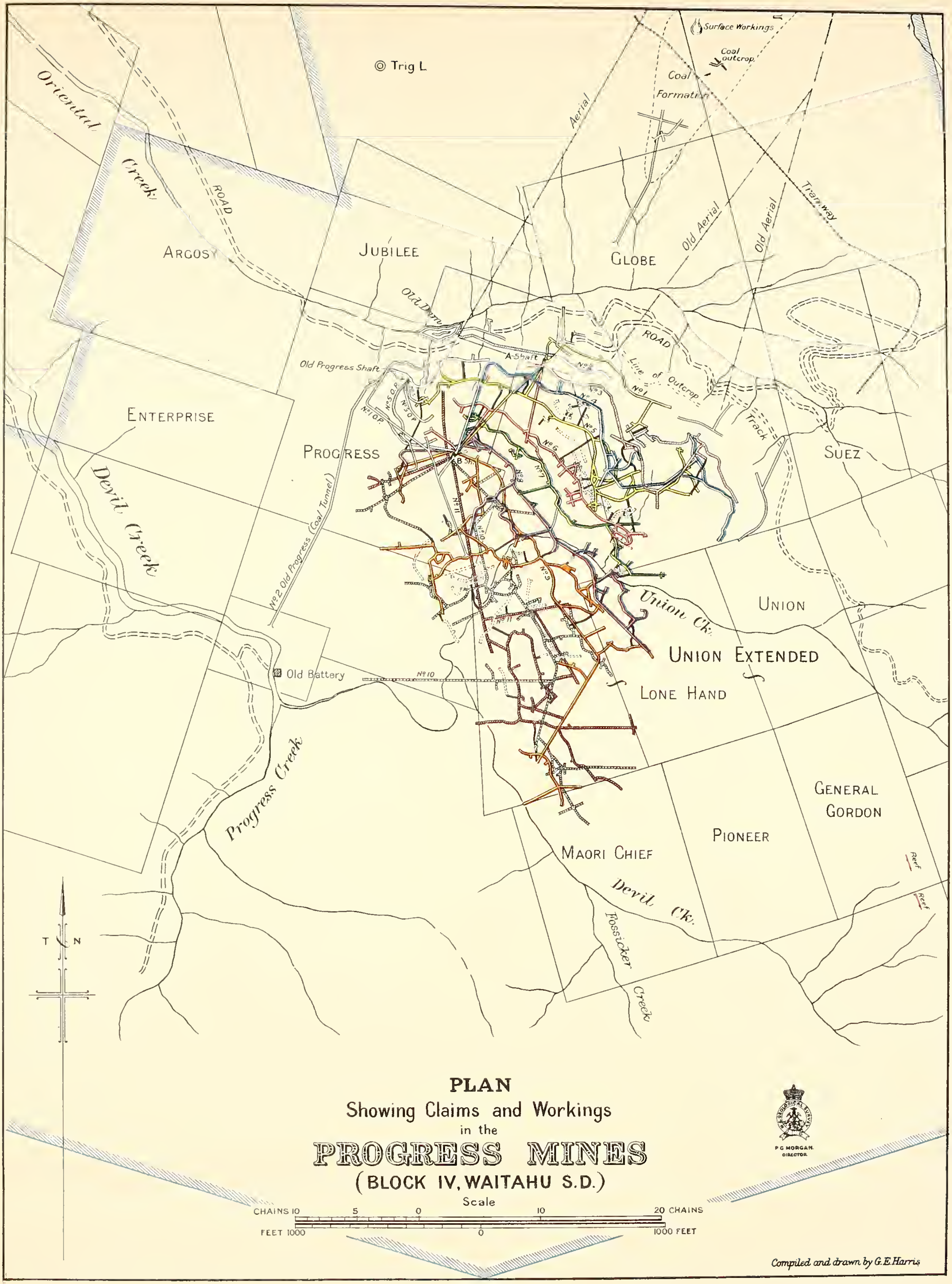
* Rep. Geol. Explor. during 1882, No. 15, 1883, p. 88.



PLAN
Showing Claims and Workings
in the
PROGRESS MINES
(BLOCK IV, WAITAHU S.D.)

The most notable were known as the Golden Hope and Merrie England, but none were found worthy of systematic exploration.

The returns from the Maori Gully group of mines are given in the table printed on page 174.

Merrijigs Group.

History.

In February, 1872, the brothers Adams discovered a "mountain of quartz"—the "Big Blow"—near the head of Rainy Creek. Owing to the difficulties of transport, and the fact that the ore was not of such high grade as that of the Murray Creek mines, it was not until 1876 that crushing commenced, the Rainy Creek Company completing a steam-driven 15-head mill at a cost of £6,000 in that year. The ore was much poorer than was expected, giving a return of only 2 dwt. per ton. The company collapsed, and Messrs. Graham and Allen, who had erected the battery, purchased the mine and mill for a nominal sum. The new owners worked the property intermittently, just so long as the mill would run without renewals and repairs; and their returns, which are not available, are reported to have been very poor. In 1876 another company, the Inkerman, started operations on a claim farther to the west, of which the lode (first prospected by Joseph Potter) was large, being often more than 20 ft. in thickness. After several years had been spent in development, arrangements were made with Graham and Allen, the owners of the Rainy Creek battery, and about 800 tons of ore was crushed at the latter's mill for a return of rather more than £1 per ton. Seeing that the charge for crushing was 15s. per ton, this yield was unpayable, and stoping operations were suspended. In 1884 the company finished the erection of a 30-head battery, which at that time was the largest and most up-to-date mill in the district. This enterprise was speedily justified. The ore improved in quality as it was followed down, and, although no dividends were paid, the heavy liabilities of the company were discharged from the profits. Unfortunately, after two years' continuous work the lode, which had been mined to a depth of 340 ft. below the surface, cut out and could not be picked up again at a greater depth.

Meanwhile, however, a more persistent "line of reef" or lode-series had been discovered farther west. In 1882 prospecting commenced in the Happy Valley Claim at the head of Slab Hut Creek, but nothing of note was found in this locality until June of 1887, when Robert Lees prospected the Sir Francis Drake. Other finds were quickly made: thus the Inkerman West was found in March, 1888, by Henry Evans, the Scotia by Robert Robin, and later the Gallant. Developments on the new claims were considered satisfactory; the Drake erected a steam-driven 15-head battery in Slab Hut Creek, and the Inkerman constructed an aerial tram 73 chains in length connecting the new lode with their plant in Rainy Creek. This latter company was successful; for several years dividends were paid, but in 1892 the reef was lost, and the company, after prospecting for some time, went into liquidation. The Sir Francis Drake began crushing in 1889, but the returns were decidedly poor. The Scotia, however, which had its ore treated at the Drake battery, was found to contain very good ore, and dividends were paid. The lode in this claim, however, soon cut out, and attempts to locate its continuation were unsuccessful.

In 1888 Messrs. Graham and Allen promoted the Supreme Company, which took over their interests in the old Rainy Creek properties. The new owners drove a low-level tunnel, developing a large amount of ore. The yield from a crushing, however, was exceedingly poor, and the company was wound up.

The Cumberland lode, which so far has been the most remunerative of this group, was found about the middle of 1890. Next year a steam-driven 15-head mill was erected in Deep Creek, and yielded returns which enabled £13,800 to be distributed in dividends in five years. The reef, which throughout was greatly disturbed and faulted, was finally lost, and has not since been located. In 1898 a cyanide plant was erected by a syndicate to treat the accumulated tailings, and the success attending this venture forcibly brought under the notice of mining men in this district the fact that their extraction methods saved barely one-half of the gold in the ore.

Meanwhile the Sir Francis Drake and its neighbour the Gallant struggled on in an endeavour to make the low-grade ore, which occurs in large quantities in both claims, pay expenses. In this, although the Gallant paid a dividend, they were on the whole unsuccessful, the Gallant going into liquidation early in 1894, and the Drake shortly afterwards. The plant and claim of the latter were acquired by a working-party, who did better than the company—sufficiently well to induce them to sink the shaft another lift. In 1900 the property was taken over by a company—the New Scotia—which held in addition the Scotia, Gallant, and Happy Valley claims. An up-to-date cyanide plant was erected, and the accumulated tailings treated, with a handsome profit. Attention was also directed to the Gallant section of the property, in which a considerable amount of work was done. The ore developed, however, was unpayable, and in 1904 the property was taken over by a syndicate, who, after sinking "Martin's winze" and taking out an unsatisfactory crushing, ceased operations in 1905.

In 1896 a company known as the Inkerman Combined Mines was formed in London, and acquired a group of old claims of which the Rainy Creek (or Supreme) and the Inkerman were the most important. In February, 1897, an extensive scheme of development was initiated, of which the chief feature was a low-level adit driven from Rainy Creek to the Inkerman shaft, a distance of nearly 3,800 ft. A great deal of development-work was also carried out, and much ore was opened up. The company, after being reconstructed as the New Inkerman Mines in 1899, began crushing in 1900 with 15 heads of the old battery that had been again brought into commission. Unfortunately, the ore was of too low a grade, and other financial arrangements were rendered necessary. After further developmental work crushing was recommenced in 1903. For two years the ore yielded a small profit, but in 1905 the returns became unpayable, and the mortgagees sold the machinery and claim to the Consolidated Goldfields. This company, after taking out a trial crushing with unsatisfactory results, shut down the mine and dismantled the plant.

In 1901 a company known as the Industry took up the Cumberland Claim and the ground immediately to the north, which had previously (1895–97) been known as the Exchange, and prospected in part from the surface and in part from the deeper workings of the Cumberland into which it had been absorbed in 1897. In 1903 the Industry, together with the Golden Lead group of claims, was merged into the United Mines. A considerable amount of prospecting was carried out by the company, and some good ore was found, but the lode was so broken and shattered that it could not be followed, and the United Mines was wound up in 1905.

The Consolidated Goldfields in 1912 acquired most of the claims formerly held by the New Scotia and United Mines, and, after repairing several levels in the Cumberland and Drake claims without result, decided to sink the Sir Francis Drake shaft a farther depth of 300 ft., a work which was proceeding at the time of the writer's visit in 1913, but has since been temporarily suspended.

Workings.

Rainy Creek and Supreme Mines.—The great mass of quartz known as the "Big Blow" has no counterpart in the Reefton district. It consists of a mass of quartz 100 ft. wide by 150 ft. in length, culminating in a point projecting 30 ft. above the surrounding surface. The longer axis has a strike about 15° west of north, a direction continued southward by broken quartz outcrops for more than 300 ft., until the Palæozoic rocks disappear beneath Miocene strata, while northward irregular ore-bodies occur on the same line for about 200 ft. The Big Blow is said to have terminated below in a rounded surface "like the hull of a ship," which rested on "good reefing country," but no track downward could be found. The plans of the earlier workings are not available, and the information obtained by the writer concerning this unique occurrence is of the scantiest.

In 1888 good ore was found on the western boundary of the Supreme Claim, a winze 40 ft. deep was sunk, and later a drive 180 ft. below the outcrop and 360 ft. long was put in. In 1890 another drift on quartz 260 ft. long and running nearly east and west is recorded, but no plans are available of this or the previous workings. In 1893 the Inkerman Company tested the Lady Louisa outcrops, originally discovered by Edward Carton, by means of short drives, but the ore extracted yielded only 3 dwt. of gold to the ton. In the same year a winze was sunk on the Big Blow and some ore crushed, but the results were very poor. In 1897 the Inkerman Combined Mines commenced extensive operations in this locality. In the Big Blow - Supreme section of the property what are known as the Golden Gully workings proved the existence of a large amount of ore in direct continuation with the Big Blow, but this was evidently of very low grade or very broken, for there is no record of any crushing from this point. This company, and later the New Inkerman Mines, drove No. 2 and No. 3 Supreme levels. In the south branch of No. 2 level a very large ore-body was opened up, but No. 3 level, which penetrated beneath the Big Blow and Golden Gully workings, appears to have missed quartz—at least, no prospecting-drives from the main crosscut are shown on the plans available. A similar statement seems to be applicable to No. 4 Supreme, driven beneath the Lady Louisa outcrops. The same company drove a low-level tunnel from Rainy Creek westward into the Inkerman Claim, and from this tunnel, 1,033 ft. from the entrance, projected a crosscut known as No. 5 south drive to the Supreme lode, which at this level proved to be very wide (45 ft. wide, but mixed with mullock) and about 400 ft. long. From this drive an incline shaft was sunk to a vertical depth of about 200 ft., and levels opened at 100 ft. and 200 ft. respectively. In these the lode was found to be from 3 ft. to 57 ft. wide, and of a length corresponding with that shown in the upper levels. Unfortunately the grade of the ore was low, and a succession of small faults added considerably to mining-costs. There was a proposal to deepen this shaft and prospect the ore underfoot, but as the quartz above had barely paid working-expenses, and as it was unlikely that the deeper levels would recoup the capital required for this work, this project was not carried out, and the mine was shut down.

The workings described above show that the Supreme lode had a strike of about 50° east of north, with a dip of about 65° to the south-east. It seems probable that the Big Blow also has an easterly dip, but the workings are not extensive enough to permit of a positive statement.

Inkerman Mine.—The lode worked by the original Inkerman Company runs through the hill on which Trig. B is situated. It was found in January of 1876 by Joseph Potter, and the company, of which the history has been sufficiently indicated on the preceding pages, was registered shortly afterwards. The reef was large, up to 200 ft. in length and often 20 ft. in width, and was worked to a depth of 340 ft. below the outcrop before being lost. Three levels were opened, and the workings were extended 40 ft. below No. 3 or the 300 ft. level by means of a horsewhip. In 1896 the Inkerman Combined Mines retimbered No. 3 level and extended it 800 ft., much of which distance was driven on "lode formation"—that is, fault gouge. The same company threw out a branch drive, known as No. 3 south drive, from their main low level and prospected the country beneath the upper workings, with which connection was effected by a rise. No ore was found in these workings, and after the reconstruction of the company in 1899 no further work was done in this portion of the property, all the attention of the management being directed to the Supreme section. The workings above described indicate that the strike of the lode was from east and west to east-south-east, with a steep southerly dip.

Inkerman West Mine.—The Inkerman West is the most northerly of a group of claims distributed along Lees' lode-series (line). It was discovered by Henry Evans in March of 1888, and was traced on the surface a distance of 350 ft. Development was by a surface winze, but later a vertical shaft was sunk close at hand. This shaft ultimately attained a depth of 423 ft., and from it four levels were opened. No. 1 level, 68 ft. from the collar, connected with the drift from the winze first sunk; and in this level the ore was driven on for a total length of about 330 ft. and was from 18 in. to 5 ft. wide, with an average of perhaps 3 ft. No. 2 level, 218 ft. down the shaft, opened up ore from 1 ft. to 7 ft. in width for a distance of 220 ft. No. 3 level, driven at a depth of 318 ft. from the surface, was on ore for a length of only 50 ft. A winze from No. 3 was sunk to a depth of 60 ft., but in its lower part the lode was very broken. An intermediate, 45 ft. below the No. 2 level, opened up 107 ft. of quartz averaging about 3 ft. in width. No. 4 level, at 423 ft., formed part of the low-level adit driven by the Inkerman Combined Mines from Rainy Creek. In it no ore was developed, but a good "reef-track" striking nearly north and south was followed for a length of more than 300 ft.

From the workings shown on Plan 12 it may be gathered that the lode had a general strike of about 50° east of north, with a steep south-easterly dip, which changes to a westerly one in No. 3 level. If this lode belongs to Lees' series its strike should be a little west of north, and its dip westerly. The change in strike and dip has probably been brought about by faulting, which has displaced that portion of the lode which has been worked. The evidence for this is found in the change in dip between No. 2 and No. 3 levels, the fault-dragged ore in No. 3 and in the winze below it, and the flaky walls of the lode in No. 2 level and lower workings. This fault apparently had a nearly north-and-south strike, a suggestion supported by the strike of the ore in No. 3 level and again by that of the "reef-track" driven on in No. 4. It is probable that the fault has a westerly dip, as shown by the change in dip of the lode between No. 2 and No. 3 levels, and indicated by the topography and by the depressed position of the Miocene rocks lying to the west of the shaft. If this be the case the "reef-track" followed in No. 4 cannot be the fault cutting off the lode in No. 3, but probably corresponds to the track driven on from the crosscut pushed for a small distance towards the original Inkerman lode in No. 3 level.

The lower lost portion of the ore-shoot ought to be found on the eastern side of the zone of displacement, and northward of any of the present underground workings. It may reasonably be assumed that the fault is post-Miocene in age, and in this case it is doubtful if denudation has sufficiently advanced to cause the lode to again outcrop.

Inkerman South Claim.—Auriferous quartz was found on the Inkerman South lease in July, 1890. It was very rich, 90 tons giving a return of 3 oz. per ton, but the ore was very broken, and no well-defined lode could be discovered. The surface in this locality was energetically prospected in the "nineties," and still occasionally receives attention.

TABLE SHOWING YIELDS FROM THE MERRIJIGS AND GOLDEN LEAD GROUPS OF MINES.

Year ended	Rainy Creek and Supreme.		Inkerman and Inkerman West.			Gallant.			Sir Francis Drake.		Cumberland.			Golden Lead.		A1.			Merrijigs.	
	Tons.	Oz.	Tons.	Oz.	Div.	Tons.	Oz.	Div.	Tons.	Oz.	Tons.	Oz.	Div.	Tons.	Oz.	Tons.	Oz.	Div.	Tons.	Oz.
Mar. 31—					£			£					£					£		
1877 ..	1,632	167	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1878 ..	..	..	787	165	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1879 ..	..	..	772	217	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1880 ..	150	42	..	118	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1885 ..	..	..	7,561	2,565	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1886 ..	..	..	11,100	2,775	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1887 ..	..	..	800	262	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1889 ..	..	..	..	..	..	1†	12†	..	1,475	295	..	..	..	..	..	..	..	..	..	..
1890 ..	..	..	1,658*	2,195*	2,000*	593†	1,272†	3,000†	2,246‡	455‡	..	..	..	100	22	..	..	..	..	..
1891 ..	..	..	4,083	2,754	2,000	674	141	..	396	99	609	630	1,200	52	67	6	124	..	85	35
1892 ..	..	..	1,088	894	..	1,083	446	600	60§	17§	3,021	2,808	3,000	2,419	611	..	..	..	..	..
1893 ..	400	17	393	165	..	224	63	..	..	..	3,952	4,304	6,600	5,439	937	3	43	..	..	..
1894 ..	..	..	..	..	..	55	9	..	1,722	343	3,968	2,068	2,400	2,435	465	6	35	..	..	..
1895 ..	..	..	..	..	..	..	..	..	1,900	565	722	785	600	341	114	42	374	..	..	..
1896 ..	..	..	..	..	..	..	..	..	1,045	315	523	572	..	42	39	83	570	150	152	25
1897 ..	..	..	60	27	..	..	..	..	1,150	447	125	128	..	18	132	78	483	100	..	..
1898 ..	..	..	..	..	..	..	..	..	1,357	465	..	..	..	480	196	56	176	50	..	..
1899 ..	..	..	..	..	..	..	..	..	1,574	563	115	1,726	..	24	30	354	155	..	20	24
1900 ..	..	..	..	..	..	..	..	..	1,237	305	861	203	..	..	..	490	210	..	..	..
Dec. 31—																				
1900 ..	2,603	165	..	..	..	..	..	..	900	584	..	..	..	..	..	44	85	..	..	..
1901 ..	149	145	..	..	..	..	..	..	173	1,124	..	..	..	..	..	160	102	..	..	..
1902 ..	..	..	..	..	..	..	..	..	..	..	182‖	29‖	..	..	..	3	6	..	..	..
1903 ..	5,247	1,373	..	..	..	..	..	..	744	162	211	147	..	11	16	15	85	..	..	..
1904 ..	8,139	2,624	..	..	..	..	..	..	479	189	118	83	..	..	..	20	55	..	..	..
1905 ..	3,894	735	..	..	..	..	..	..	250	47	..	..	..	..	..	..	..	..	..	..
1907 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	18	24	..	..	..	..	..

* This and subsequent yields are from the Inkerman West. † Scotia. ‡ Includes a yield of 29 oz. from 127 tons from the Happy Valley. § Hard-to-Find. ‖ This and subsequent yields are from the Industry.

Scotia Mine.—Rich ore was found in this lease early in 1888 by Robert Robin, and shoad was traced north and south nearly across the claim. Two winzes were sunk, 30 ft. and 200 ft. respectively from the south boundary, and a crosscut driven from Scotia Creek connected with the south winze in a distance of 320 ft. In all only 67 ft. was driven on ore, which averaged about 2 ft. in width. This level was later extended several hundred feet northward, and also south 50 ft. into the Gallant Claim, which adjoins the Scotia in that direction, without disclosing anything of value. A winze was also sunk from the adit on the small block first developed, but after sinking 25 ft. the ore cut out. The winze eventually was sunk to 140 ft., and crosscuts driven into the walls. The first crosscut, 45 ft. down, located ore 1 ft. thick in the foot-wall, but the other, at 75 ft., although produced 80 ft., disclosed nothing, and in 1893 the claim was abandoned.

The ore in this claim was high grade, but beyond the small ore-body first found nothing of consequence could be discovered, although the surface was faithfully prospected. The workings, surface and underground, show that the original lode must have been much shattered by faults, a condition which also extends into the Inkerman South. The chief faults in this locality evidently belong to the Black's Point system, but north-and-south fractures parallel to the neighbouring Murray Creek zone have probably had more to do with the shattering of the ore-bodies.

Hard-to-Find Mine.—The small lode of this claim, which lies to the west of the Scotia, strikes a little west of north, and fills an unimportant fracture parallel to the main ore-channels of Lees' lode-series. A winze 60 ft. deep was sunk on the outcrop, here 2 ft. wide, and an adit driven which cut the quartz in a distance of 250 ft. A little stoping was done on ore from 1 ft. to 3 ft. in width, but the yield was too small to justify further work, and the claim was abandoned. No plans of the workings are available.

Gallant Mine.—This claim was pegged out early in 1888, and the vein in it was traced for more than 1,000 ft., from near the southern right to the northern boundary. A winze was sunk to a depth of 120 ft. about 5 chains from the Scotia boundary, and an adit, with its entrance beside that of the Scotia adit, was driven to the lode, which it cut in 250 ft., about 175 ft. north of the winze and 150 ft. below the outcrop. Hundreds of feet of driving was done on the lode and track, the ore being usually from 2 ft. to 4 ft. in width. Generally it was too low grade to pay, but in 1891 profitable stone was milled from a point where the lode averaged about 18 in. In 1893 the claim was abandoned, and no serious effort to explore the lode was made until 1901, when the New Scotia Company cleaned out the adit and sunk a winze. Connection was also made with the Sir Francis Drake shaft by way of No. 1 Drake level, about 250 ft. below the Gallant adit. An intermediate from the winze was also driven north on quartz from 10 ft. to 16 ft. wide. Operations were unprofitable, however, and attention was directed to opening another vein in the Gallant Claim lying 200 ft. to the west of and parallel with the Gallant lode. On this a winze, "Martin's winze," was sunk over 200 ft., and two levels were opened from it. No. 1 level was driven at a vertical depth of 111 ft. north and south on the reef, which was from $2\frac{1}{2}$ ft. to $3\frac{1}{2}$ ft. in width. No. 2 level, about 200 ft. from the surface, was driven 70 ft. on ore from 2 ft. to 4 ft. wide. The returns of the crushings from these levels were not sufficiently encouraging to warrant further work.

Sir Francis Drake and Happy Valley Mines.—The Happy Valley was the first claim on the Merrijigs Hill to receive systematic prospecting. This was as early as 1882, when McGee brothers found gold-bearing leaders in part of the claim. An east-and-west lode exists in the ground, as well as those on the main north-and-south series. A winze 60 ft. deep was sunk on a large quartz vein near the head of Slab Hut Creek; some driving was also done, and a small crushing taken out, but the ore proved hopelessly unpayable.

The Sir Francis Drake lode was discovered by Robert Lees in 1887, and was traced on the surface for 250 ft., showing a maximum width of 5 ft. A crosscut driven 35 ft. below the outcrop cut the lode in 60 ft. at a point where it was 8 ft. in thickness. A second adit, 115 ft. below the first, struck the lode in 260 ft.; and in this adit the quartz varied up to 9 ft. thick, with an average of, say, 3 ft. The ore taken from this level was of rather low grade, and for some time little work was done, but in 1892 a shaft was sunk and a level opened at 190 ft. from the surface. Three small blocks were opened up, of which two were each about 80 ft. in length, and the third and most northerly about 70 ft. A cross-drive from the lower adit also got unpayable quartz in the Happy Valley ground. In 1899 a second level was opened from the shaft at a depth of 330 ft., and an ore-body 80 ft. long by 3½ ft. wide was developed, but evidently did not yield a very profitable return, for work was soon suspended. Later the New Scotia Company did a good deal of prospecting from the shaft levels on the Happy Valley lode and also in the Gallant Claim, but the results were discouraging. At the time of the writer's examination of this portion of the subdivision (February, 1914) the Consolidated Goldfields had opened up the shaft again and were engaged in sinking it a farther distance of 300 ft. The faults of this and the adjoining Gallant Claim are small, and appear to have produced no important dislocation.

Cumberland-Exchange Mine.—Robert Lees, when endeavouring to trace the northward continuation of the Golden Lead auriferous belt, found a flat-lying quartz-body about 4 ft. in thickness. This was the Cumberland lode that later was found to consist of two veins, each about 4 ft. in thickness and separated by 14 ft. of mullock, the upper being red and the lower blue and unoxidized. An adit was driven 30 ft. below the outcrop, which struck ore in a vertical attitude 130 ft. from daylight. The lode was followed for 250 ft., and varied from 1 ft. to 10 ft. in width. No. 2 level, 133 ft. below No. 1, struck the "reef-track" 450 ft. from the entrance, and followed it for 140 ft. without result. An intermediate level was then driven from a winze below No. 1, developing about 100 ft. of ore. No. 2 was then extended 150 ft. in a northwesterly direction to the lode, which at this level was about 100 ft. in length and 10 ft. to 12 ft. in average thickness. An incline shaft of 64 ft., measured on the incline, was then sunk from No. 2, at the bottom of which the ore was very much broken, but a crosscut intersected the lode 40 ft. from the bottom of the incline. This ore-body was from 1½ ft. to 2 ft. wide, 110 ft. long, and of high grade. A vertical shaft 220 ft. deep was then sunk, and a crosscut put out to the west, in which low-grade ore was struck. A great deal of prospecting was done in this level, which was extended northward into the Exchange Claim where a fissure filled with pug and quartz fragments was followed, while southward large bodies of barren quartz up to 18 ft. wide were driven on. Winzes were also sunk, but the rich ore of the upper workings could not be traced below the first intermediate above the lowest level.

The Exchange Claim, immediately to the north, was held by a separate company until 1898, when the Cumberland and Exchange were amalgamated. The workings consist of two adits, the second being 60 ft. below the first. In No. 1 a very broken lode about 3½ ft. in maximum thickness was found, but this in No. 2 was only from 6 in. to 2 ft. wide, while prospecting at lower levels was conducted from the Cumberland workings with negative results. Later this ground was again prospected by the Industry Company, which drove an adit at the level of the main road. This drift, which was begun in Miocene rocks and passed through a thin coal-seam, cut a gold-bearing reef at 300 ft. A rise was put up to the surface, but the lode on being followed north was cut off by a fault. A winze followed quartz from 3 ft. to 4 ft. wide to a depth of 67 ft., and No. 1 level was reopened and extended to cut this block. The ore extracted yielded a profit, but a winze from No. 1 Exchange ran out of quartz at a depth of 21 ft., and was continued a farther 50 ft. along a fault-plane, in which drives north and south from the bottom of the winze were also constructed. At this time the company was merged, together with the Golden Lead, into the United Mines, a concern that shortly afterwards went into liquidation.

In the Cumberland and Exchange claims the ground was exceedingly broken and wet, conditions due to the fact that both claims lie on the western edge of the Murray Creek fault-zone. From the distribution of the broken blocks, from which the Cumberland paid its handsome dividends, it is evident that the ore-shoot pitches to the north, conforming in this respect with the generality of Reefton lodes. It is obvious, then, that the prospecting in the southern end of the lowest level had no chance of finding the Cumberland shoot, which probably lies in the Exchange ground, and might be found either by rising on the fault-plane containing the fragments of auriferous quartz or by driving westward from it. The finding of the shoot prospected by the Industry will probably present less difficulty than the locating of the Cumberland shoot, but the data available in both cases are very scanty. Another method of attack would be to drive south from the Drake shaft to the Cumberland Claim; and this scheme, though involving a much greater capital expenditure, has the decided advantage of exploring the ore-channels of Lees' lode-series south of the shaft at a greater depth than has yet been attempted.

Golden Lead Group.

History.

The discovery of the Sir Francis Drake and Inkerman West shoots in 1887–88 gave a great impetus to prospecting in the Merrijigs district, and this early in 1888 led to the discovery of a leader-zone of country which seems to have been first prospected in the O.K. Claim. It was, however, quickly traced into the adjoining Merrijigs and Golden Lead properties, and afterwards into the A1. After several years of prospecting it became manifest that no large lode existed in the auriferous zone, which consisted of shaken greywacke traversed by numerous quartz leaders that seldom preserved their identity for more than 200 ft. Several small parcels of picked ore were crushed at the Drake battery with satisfactory results, and the belief was confidently held that the leaders carried sufficient gold to make the whole zone payable if mined in a large way and cheaply transported to a battery. A water-driven 10-head battery was erected in Deep Creek by the Golden Lead, which afterwards absorbed the O.K. and Northumberland properties. Connection with the mine was effected by an aerial tram, and crushing commenced in 1892. The ore was roughly sorted in the mine, but even then the yield did not cover working-expenses, while development was continued by means of calls. In 1894 the plan of crushing the ore obtained from a full stoping width was abandoned, and the experiment of bagging the quartz from the leaders was tried, but proved no more profitable. It being impracticable, from the amount of water in the ground, to sink on the stock-work, a low-level tunnel was planned and ultimately driven nearly 1,800 ft. The company struggled along, crushing occasional parcels of picked stone, till 1903, when it was merged, together with the Industry, into the United Mines, a concern that went into liquidation in 1905.

The other claims on this leader-zone, the Merrijigs and A1 (also called for a time the Last Chance), have been worked in a desultory way since their discovery. From time to time tributers and small working-parties have followed individual leaders with fair success, and a steam-driven 5-head stamp mill on the A1 Claim has been a great convenience to these parties.

Workings.

The zone of crushed and mineralized country named after the McGee brothers by the writer has situated along it (from north to south) the Golden Lead, Northumberland, O.K., A1, and Merrijigs claims, as well as others which do not seem ever to have produced ore. The belt or stock-work varies considerably in width, and is set between hard walls. The leaders and stringers, some of which are very rich, are scarcely ever more than 1 ft. in width, and are usually very much less. An individual leader has been known to preserve its identity for 220 ft., but in general they speedily die out on being followed. The zone itself in the Golden Lead No. 1 adit, 70 ft. below the outcrop, is reported to be 80 ft. wide, but a horse of hard rock, stated to be 30 ft. through, may be here included. In No. 2 level this bar has been reduced to 12 ft. In the Merrijigs adit the width of the zone was 38 ft. (on the boundary between this claim and the O.K. 60 ft. is given), while northward in the A1 20 ft. is reported. The dip of the zone is westward, but varies somewhat. Thus in the No. 2 level, Golden Lead, the dip was between 40° and 45°, while in No. 3 it was steeper, and in No. 4 about 30°.

The writer was unable to procure copies of the plans of any of the mines on this zone, and the descriptions here given are necessarily vague. A great amount of work was done in the Golden Lead, which also includes the O.K. and the Northumberland claims. The first level in the original Golden Lead Claim, about 170 ft. below the crown of the ridge and 70 ft. below the outcrop, was driven 400 ft. on the leader-zone. No. 2 level, about 150 ft. below No. 1, was driven on the stock-work more than 700 ft. No. 3, 120 ft. below No. 2 and 50 ft. below the main road, reached the formation after crossing country for about 150 ft., and then followed a leader for over 220 ft. No. 4 adit, usually known as the "low level," is about 400 ft. below No. 2, and has its entrance in O.K. gully, and a course a little west of north. Quartz veins were encountered at 300 ft. and 360 ft. from the portal, but beyond this for 1,000 ft. the adit was in hard country, dipping about 35° to the westward. At 1,400 ft. "good reefing country" was entered, and continued to about 1,700 ft., when hard country was again met with. This belt of "reefing country" undoubtedly corresponds with the leader-bearing zone at the surface, and the writer was informed by several people that a barren vein was cut in it. On the other hand, there is no mention of such a lode in the reports of the Inspector of Mines; and Mr. J. Wills, of Reefton, who was a director of the Golden Lead Company throughout its existence, assured the writer that nothing worthy of the name of a "reef" was penetrated in this part of the tunnel. All are agreed that nothing of value was discovered.

In the A1 Claim several tunnels have been driven to the auriferous belt to tap a small but exceedingly rich leader lying on the foot-wall of the stock-work. This has been followed by tributers and working-parties for long distances. In the Merrijigs Claim a tunnel about 700 ft. in length was driven, and cut the leader-zone about 280 ft. below its outcrop. The foot-wall leader in this claim is decidedly larger but not nearly so rich as in the adjoining Merrijigs Claim.

Big River Group.

History.

Alluvial miners penetrated to the head of the Big River in very early times, while auriferous quartz seems to have been first found in this locality, in the Big River Claim, by Hugh F. Doogan in 1880. A company, the Big River, was formed in 1882 to work this find, but owing to the isolation of the claim and the difficulty of access the operations were of a desultory nature. A pack-track of a sort had reached the locality in 1881, but it was not until 1886 that it was graded well enough for the transport of machinery. Next year a 10-head mill was built, a water-race completed, and an aerial tram connecting mine and battery erected. The crushing was a great disappointment, for although the yield was at the rate of more than 25 dwt. per ton, yet so broken and irregular was the lode that this was unpayable. A new block 300 ft. to the west of the first workings was discovered, and attention was directed to its development. This proved to be less broken than that originally found, and a shaft was sunk from the end of the adit by which it was explored. To a depth of 700 ft. below this adit each level disclosed ore sufficient to pay dividends. No. 6 level, opened first in 1897, proved disappointing; and it was not until 1900 that the discovery of a small block of stone lying below this level put heart into the shareholders and induced them again to deepen their shaft. In 1907, at a depth of 1,375 ft., ore-bodies of larger size were encountered, and the yield from these has made the Big River one of the most prosperous mining companies in the Reefton district.

In 1897 the company sold the accumulated tailings for 8s. per ton to a Mr. McDonald, of South Africa, who erected a cyanide plant and treated nearly 4,000 tons for a handsome profit. The company then took over the plant and continued to work it, but later sold the plant and the remainder of the tailings, the treatment of which was completed in December, 1898. In 1908 the company, having purchased the cyanide plant at the Sir Francis Drake battery at Merrijigs, re-erected it at its own battery, and since that date has disposed of the tailings accumulated since 1898, and overtaken the current output of the mill.

Although from time to time a great deal of prospecting has been done both in the immediate vicinity of the Big River Claim and in the neighbouring district, nothing of importance has been discovered. In the "eighties" attention was directed to tracing the Big River lode southward into the Alexander Claim and northward into the Lord Edward. The latter company, of which the claim is now a part of the Big River holding, contributed to the cost of sinking the main shaft, and, having extended No. 2 level into its claim, did much unsuccessful prospecting therefrom. The No. 2 Big River also adjoined the older claim, and a good deal of resultless work was undertaken in this ground. Again, from 1908 to 1910, a claim just to the north, the Big River North, was vigorously prospected by Kirwan and party, but, although for a time the chances appeared excellent, the country was found to be so shaken that the claim was abandoned.

In 1891 John Gill found the National lode, which was driven on for 150 ft., but was too broken to be of value. Another lode-series on which much money and labour has been expended without result is that known as the Sunderland "line." This lies south-west of the Big River Township, and may be traced from there to south of the Snowy River. The first discovery on this series was made in the St. George Claim by James Sunderland, apparently in 1891. On the same "line" are the Conquest, Golden Hill, and Matthias claims. For several years the St. George was intermittently worked, and a water-driven 5-head battery was erected. A small block of ore was stoped out from a short adit, and about 30 tons crushed for a return of more than 70 oz. of gold. Other small low-grade ore-bodies were found and developed, but the returns from these were so disappointing that in 1895 the claim was abandoned and the plant sold. In 1898 another attempt was made to prove the ground, but this also came to nothing. In 1904 a little desultory prospecting was done in the St. George and in the Searchlight, a claim at the northern end of the same lode-series and within a mile of the Big River


PLAN
Showing Claims and Workings
in the
BIG RIVER
GROUP OF MINES
(BLOCKS II, III, VI & VII WAITAHU S.D.)
Scale
CHAINS 10
5
0
10
20 CHAINS
FEET 1000
0
1000 FEET
P.G. MORGAN. DIRECTOR
Trig. O
Coal Lease
Big River G.M. Co
Miocene
Coal
Coal
National
Mt Aurum
Porphyry
Tramway
Lord Collingwood
Triumph
Fault
Pilgrim
Dash
II
III
Devonian
Monarch
Fault
Fault
VI
VII
Parnell
Dolerite
Big River
Fault
Lord Edward
No 2 Adit
Battery
Formed
Track
No 2 Big River
T N
Aerial Tramway
No 1 Int
New No 1 Int
Formed
Dray
Road
Engine House
Smithy
Big River
Prima Donna
Bedouin
Columbus
Trig. P
G.E.H.

battery. The success following operations of the Big River during 1908 caused attention once more to be directed to this locality, and the whole of the Sunderland lode-series was again pegged out, and companies were formed. The Big River South held the ground at the northern end, while the St. George Quartz-mining Company acquired the St. George and Matthias claims at its southern end. Operations were unsuccessful in locating a profitable ore-body, and have since ceased.

Workings.

Big River Mine.—The underground workings of the Big River Claim are fairly extensive. Two adits are driven with their mouths close together, of which the first goes north-eastward toward the first-found outcrop, and the second north-west and then eastward to the main shaft, which it reaches at a point 220 ft. below the surface. Nine other levels have been opened from this shaft, the lowest of which is 1,575 ft. below the surface. The blocks of ore developed in the adit levels are widely separated from the other blocks. The ore-bodies developed in No. 2 to No. 5 levels are more or less connected, and the same may be said of the double blocks occurring in No. 7 to No. 10 levels. It is probable that the northerly blocks of the lower levels may be correlated with the ore-bodies so far developed in the upper levels, except in the case of that in No. 2 level. The southerly ore-bodies of the lower levels would then correspond with the original Big River block that was also located in No. 2. In this case two original ore-shoots would be indicated, and further prospecting toward the south-east in No. 3 to No. 6 levels is advisable.

The ore-bodies so far developed are so broken and have an orientation so varied that it is impossible to state definitely what the strike of the lode originally was. It is apparent, however, that the lode had an easterly dip and a northerly pitch ; and the writer is inclined to believe, from the distribution of the scattered blocks of ore and from the strike of the principal faults of this locality, that a westerly-dipping fault-zone with a strike a little east of north has shattered the original lode. The workings have not yet penetrated beyond the limits of this zone, for although the lower levels have disclosed far more ore than has yet been discovered in the upper levels, the country is just as shaken and faulted in the deepest level as on the surface.

Other Claims.—The underground workings of the other claims in this group are very imperfectly known by the writer. The National ground was not inspected, but the country is reported to be very broken, and a wide fault-zone striking toward the claim shows on the road-line close at hand. In the Big River North a large " reef-track " containing fragments of auriferous quartz was followed for a long distance. This was undoubtedly one of the post-mineral fault-planes so numerous in this locality. In the St. George Claim a formation about 12 ft. wide on the surface showed broken quartz and a leader from 3 in. to 8 in. thick. A low level driven from the Snowy River fall followed a fault-plane containing broken quartz, with walls well slickensided, for many hundreds of feet. The Big River South Company drove on a similar, perhaps the same, fault-plane in their claim. It is evident that an ore-channel probably carrying several shoots has been reopened by later movements, and has had its contents and walls again crushed.

A table showing the yields of the Big River Mine will be found on page 174.

Blackwater Group.

History.

The first record of prospecting in this locality is that of the work done by the Snowy Creek United Company, which in 1898 sank a winze 118 ft. on a lode which averaged 2 ft. in width. Next year tributers, Messrs. Duffy and Rogers, erected a

5-head battery and drove a level from the winze. The crushing they took out gave but an indifferent yield, and in 1900 the company took over the tributers' plant and did some further prospecting. Evidently the results were unsatisfactory, for the property was abandoned.

In November, 1905, William Martin, a member of a subsidized prospecting party, discovered the outcrop of a 2 ft. lode in Greek Creek, a small tributary of Snowy River. The property was acquired by Mr. P. N. Kingswell, who, after spending a considerable amount in development, disposed of it to the Consolidated Goldfields of New Zealand and Progress Mines. These companies further opened up the lode, chiefly by surface winzes, and afterwards formed the Blackwater Mines Company in order to take over and work the property. A battery having been built, crushing began in July, 1908, and has continued up to the present date, save for a six-months interruption in 1912 due to a strike. The treatment plant consists of a 30-head mill, with tube mills, concentrating-tables, and cyanide plant. Power is supplied in part by a Pelton wheel driven by water drawn from Snowy Creek, and in part by a suction-gas plant, which is brought into commission when the water-supply is insufficient.

The success attending the development of the Birthday lode (Martin's reef) stimulated prospecting in the vicinity. The efforts made to trace this lode northward into the Prohibition Claim and southward into the Blackwater South lease have not been over-successful. At the present time Mr. David Ziman is sinking a shaft in the Prohibition Claim to catch the Blackwater shoot in depth, where its northerly pitch takes it out of the Blackwater Mines' ground. A company has been formed to develop the Blackwater South in depth, but at the time of the writer's visit operations to this end had not commenced. This company also hold ground in which occur the Snowy Creek as well as the Empire and Imperial lodes, of which the two latter are, for practical purposes, still undeveloped.

In 1911 a gold-bearing lode was found on the north bank of the Snowy, about two miles to the west of the Blackwater lode. In the early days a miner in his search for alluvial gold had uncovered gold-bearing quartz in this locality, and on the strength of his statements the Millerton Syndicate sent out J. Danks to prospect the ground, with the above result. Several adits were driven, one of which followed the lode for several hundred feet, and the prospects were considered so encouraging that a company was formed to develop the property on a larger scale.

This lode-series, to which the writer has given the name of "Danks," has been traced northward beyond the Blackwater in Saraty's lease, and again beyond the Big River in Lee's discovery. At the time of the writer's visit the surface show on both these properties was encouraging.

Workings.

Blackwater Mine.—A shaft has been sunk about 200 ft. west of the line of outcrop, and from it levels have been opened at depths of 150 ft., 305 ft., 430 ft., 615 ft., 765 ft., 925 ft., and 1,075 ft. from the brace. An adit known as the north tunnel has been driven northward from Greek Creek for more than 1,200 ft., while No. 2 level is the original Joker adit. A low-level adit, which strikes the shaft at a depth of 490 ft., connects with the mill. These workings prove that the Blackwater lode is the most regular in the Reefton district, and that it varies up to 6 ft. in width, with an average of about 2 ft. The dip is to the westward at about 80°, and the strike approximately 30° east of north. Three shoots exist with a pitch to the northward of 38°; the most southerly shoot is about 800 ft. long, the central nearly 1,400 ft., while in the case of the northern shoot the work so far undertaken is insufficient to prove its length. The blank ground between these shoots is quite inconsiderable, and in places they probably

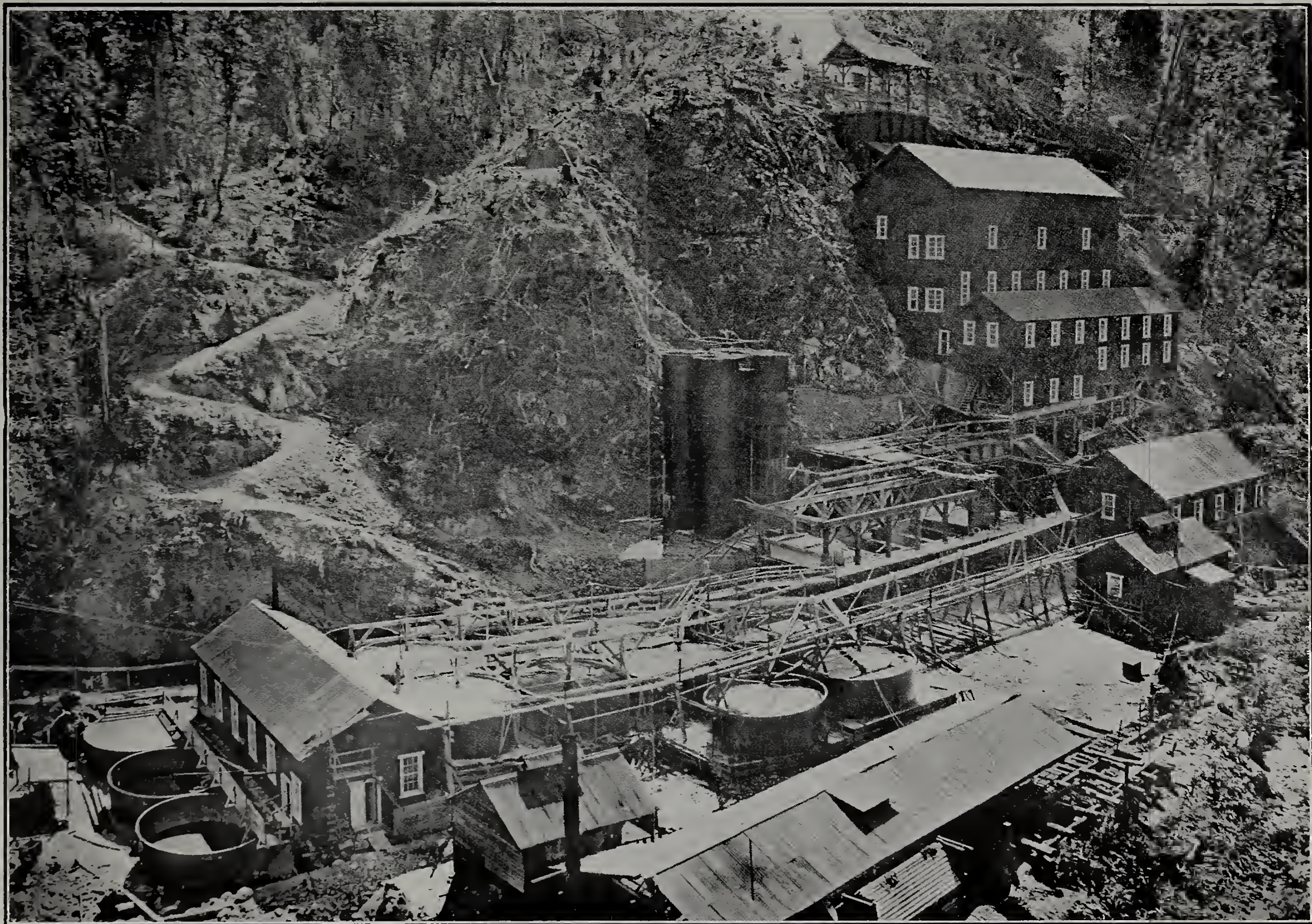


Plate X.—Blackwater Mine: Treatment Plant.

Face p. 172.]

merge into each other. In 1915 a new ore-shoot 400 ft. long was found in No. 6 level, south of the most southerly shoot. This is not yet fully developed, but is probably only a widening of the stringer followed in the southern portion of the Joker adit. The developments at the northern end of the lease indicate that some fault-movement has taken place, and this is further borne out by the fact that the Prohibition crosscut driven just outside the claim failed to find ore. The more probable explanation, however, is that no ore-shoots exist in this fissure north of those already mentioned, and that the broken ground represents the shattered country usually found at the edge of an ore-shoot. In the southerly portion of the property some driving has been done on the Snowy lode, but the results were discouraging, the vein being small and broken.

Blackwater South Claim.—The Blackwater South property is still in the prospecting stage. A crosscut 300 ft. long has been driven on the south bank of the Snowy River to the Birthday fissure, which here contains only broken ore; it is obvious that a fault, or rather fault-zone, striking west of north, crosses the lode-channel about this point. The drift, which follows the fissure for about 200 ft., so far has disclosed nothing of value. Other auriferous lodes traversing the ground are the Snowy, Empire, and Imperial, and on these some work has been done. A small outcrop of auriferous quartz occurs in Kiwi Creek, a small branch of Brown Creek. This strikes 20° east of north, dips westward at 60°, and probably belongs to the Snowy lode. Near the head of the same creek the Imperial lode shows about 1 ft. of stock-work, striking 35° east of north, and dipping very steeply to the eastward. Between these lies the Empire lode, to which two adits 150 ft. apart have been driven from the valley of Quartz Creek, a tributary of Snowy River. The shoot of ore in the lower adit strikes 15° east of north, and dips steeply westward. It is 115 ft. long, averages 8 dwt. per ton, but is only 16 in. wide.

Prohibition (or Blackwater North) Claim.—Mr. David Ziman holds an option over this claim, and is sinking a shaft to explore the ore-shoots from the Blackwater Mines that will in depth inevitably enter the Prohibition ground. Surface prospecting on this claim disclosed nothing of value, and its future depends entirely on the developmental work to be undertaken from the shaft.

Other Claims on or near Martin's Lode-series.—Mr. Donald McDonald has for several years prospected a belt of likely looking country which crosses Blackwater Creek somewhat to the west of the line of the Birthday reef. Although several gold-bearing leaders have been intersected and followed, nothing of value has so far been found, and work has now ceased. A powerful fault manifestly disturbs the country at this point.

A few chains north-east of Trig. Station M a phenomenally rich leader was worked during 1906 by Hurley and party. The country was faulted, however, and the gold-bearing leader could not be found, although some half-dozen other veins were prospected, beyond the fault.

Millerton Mine.—An adit has been driven into the north bank of the Snowy River along the lode-channel. Although the valley-walls have here a considerable height, they have been carved for the most part from post-Tertiary gravels, and the tunnel is some small unknown depth beneath the old land-surface. Thus the country is strongly oxidized throughout, and some 300 ft. from its mouth the adit passes into well-consolidated gravel. Two ore-bodies have been developed, of which the first, at the mouth of the adit, is only 30 ft. long by 2 ft. wide; the second starts at 250 ft. from daylight, and is 3 ft. wide, with an unknown length. Winzes have been sunk on both ore-bodies, but only to a depth of a few feet, owing to the amount of water in the ground. Later a shaft was sunk east of the lode to a depth of 170 ft., and a crosscut driven to the lode. So far developments at this depth have been disappointing.

In the writer's opinion this claim is situated too near the edge of the Palæozoic sediments to be beyond the influence of the peripheral faults bounding the block. Proofs of faulting were noted on the south bank of the Snowy both above and below the lode, while the broken nature of the country and the reef-track in the adit, and the fact that the lode-channel has not yet been located to the south of the Snowy, are significant. Again the description given the writer of the reef-track in the shaft level is strongly suggestive of a lode faulted along its strike. Prospecting should be toward the north, as in that direction the ore-channel increases its distance from the main fault-zone.

Table showing Yields from the Big River, Maori Gully, Blackwater, and Paparoa Groups of Mines.

Year ended	Big River.			Various.		Blackwater.			Taffy.		Crœsus.		Minerva.	
	Tons.	Oz.	Div.	Tons.	Oz.	Tons.	Oz.	Div.	Tons.	Oz.	Tons.	Oz.	Tons.	Oz.
Mar. 31—			£					£						
1879 ..	..	..	..	*2	*25	..	..	..	..	..	..	..	..	..
1884 ..	..	..	..	*1,000	*271	..	..	..	..	..	..	..	..	..
1888 ..	510	645	..	..	..	..	..	..	..	..	..	..	..	..
1889 ..	335	443	..	..	..	..	..	..	..	..	..	..	..	..
1890 ..	700	350	..	..	..	..	..	..	..	..	..	..	..	..
1891 ..	..	..	..	†66	†12	..	..	..	..	..	..	..	..	..
1892 ..	1,652	3,704	..	..	..	..	..	..	..	..	..	..	..	..
1893 ..	1,444	2,555	4,200	‡54	‡44	..	..	..	..	..	..	..	532	131
1894 ..	2,690	3,979	9,900	..	..	..	..	..	..	..	..	..	228	120
1895 ..	1,760	2,560	4,200	..	..	..	..	..	..	..	..	..	1,610	506
1896 ..	3,736	4,026	10,800	..	..	..	..	..	..	..	..	..	90	14
1897 ..	2,000	1,983	1,800	..	..	..	..	..	..	..	..	..	..	..
1898 ..	480	1,011	..	..	..	..	..	..	..	..	..	..	..	..
1899 ..	730	1,420	900	..	..	..	..	..	?	30	750	590	..	..
1900 ..	1,225	1,565	4,800	‡25	‡18	..	..	..	275	153	1,092	865	..	..
Dec. 31—														
1900 ..	216	113	..	..	..	‖139	‖47	..	873	319	1,643	858	..	..
1901 ..	75	30	..	..	..	‖20	‖3	..	?	16	272	102	..	..
1902 ..	..	..	..	..	..	..	..	..	180	24	..	..	..	..
1903 ..	340	453	1,166	..	..	..	..	..	303	66	1,000	242	10	4
1904 ..	988	902	..	..	..	..	..	..	..	..	..	..	..	..
1905 ..	920	879	..	..	..	..	..	..	..	31	..	1	..	..
1906 ..	2,037	1,940	2,333	..	..	..	..	..	100	30	..	..	..	..
1907 ..	685	1,059	..	..	..	..	..	..	380	121	..	..	..	..
1908 ..	4,851	7,736	..	*100	*16	9,169	4,681	..	320	111	..	..	..	..
1909 ..	5,434	5,886	15,600	..	..	29,955	16,418	12,500	120	36	..	..	..	..
1910 ..	3,040	4,112	5,400	..	..	39,192	23,368	37,500	200	75	..	..	..	..
1911 ..	6,913	7,317	13,200	..	..	44,038	23,557	37,496	..	..	..	..	..	..
1912 ..	7,666	9,372	15,600	§9	§17	11,538	6,844	..	..	..	..	..	..	..
1913 ..	4,970	6,995	14,400	§20	§2	45,053	20,940	12,500	..	..	..	..	..	..
1914 ..	6,273	7,467	9,600	..	..	50,426	23,400	12,500	..	..	..	..	..	..

* Golden Point. † National. ‡ St. George. § New Discovery. ‖ Snowy Creek.

Paparoa Group.

An area of greywacke forming a part of the Paparoa Range, and drained by the headwaters of Moonlight, Blackball, Ten-mile, and Canoe creeks, is known to contain innumerable quartz lodes, many of which are large and have been traced for long distances. The streams above mentioned, and especially the first-named, have yielded to the alluvial digger large amounts of coarse hackly gold, to which quartz is often attached. In the upper basin of Moonlight Creek rich shoad ore was early discovered, and a Christchurch company placed an 8-head battery on the ground in 1868, but the lode shedding the auriferous quartz was not found, and the ground was soon abandoned. Prospecting continued, however, and claims were located over a wide area between

Moonlight and Ten-mile creeks; but by 1872 all these had lapsed. In 1877–78 the Moonlight-Blackball area again received attention, but nothing of value was discovered.

In 1889 the Minerva lode, the outcrop of which in the gorge of Blackball Creek had been known for years, was found to be auriferous. A company, registered February, 1890, in spite of the enormous difficulties of transport, had erected a 10-head mill by 1891. In all about 2,500 tons were crushed for a yield of between 6 dwt. and 7 dwt. per ton. The lode, which has a west-south-west strike and a flat dip to the southward,* varies from 4 ft. to 10 ft. in thickness, and consists of nicely laminated quartz. The principal workings are approached by an incline adit driven on the dip for a distance of 376 ft., the lower portion of which has a grade of 1 in 7 only. Most of the work in connection with the Minerva Claim was done in 1894–95. In the late "nineties" the property was acquired by Mr. Gerald Perotti, who from time to time has done a little prospecting on his holding, but without meeting with success. At the time of the writer's visit the workings were filled with water, and could not be inspected.

The most promising of the Paparoa group of claims was the Crœsus. The ore-shoot of this claim was discovered in 1897 by Harry Neilson, who traced the shoad from the Ten-mile fall to the prominent outcrop on the very crest of the mountain-ridge. A 10-head battery purchased from the Specimen Hill Company was erected in 1898, and for several years the returns were satisfactory, and dividends to the extent of £719 were paid. In 1902 the company was reconstructed as the Mount Paparoa, and in 1904 the claim and plant were purchased by the Garden Gully Gold-mining Company. The battery and aerial tram were shifted into the valley of the Roaring Meg in 1905. The last work done on the claim was in 1911, when No. 4 adit was driven.

The ore-shoot worked by the Crœsus Company had a nearly north-and-south strike, an eastward dip of about 35°, and a decided southerly pitch. It had a length of about 100 ft., and was from to 2 ft. to 8 ft. wide, with an average stoping width of, say, 5 ft. In all, three adits were driven on the shoot, the ore from which in the two upper levels yielded 16 dwt. per ton. Mr. T. O. Bishop, Inspector of Mines, informed the writer that a rich leader, occurring about 2 ft. in the hanging-wall, was mined with the main ore-body. Below No. 2 adit this leader was lost, and the ore later supplied to the mill was unprofitable. The lowest workings on ore are in a winze sunk 27 ft. below No. 3, and there the quartz is reported still to show gold. No. 4 adit, 284 ft. below No. 3, did not strike ore. A large quartz lode striking north-north-east has its outcrop close to that of the Crœsus ore-shoot, and numerous other quartz lodes also striking north-north-east have been cut in developmental work.

The Garden Gully lode seems to have been first prospected in 1897, but it was not until August, 1901, that the Garden Gully Gold-mining Company was registered. The battery, erected in 1905 at great expense, crushed for a very brief period the ore proving of very low grade, and the company shortly afterwards went into voluntary liquidation. Three adits in all were driven, establishing that the lode had a north-north-east strike and a steep easterly dip. A large mass of quartz from 9 ft. to 12 ft. thick was struck in the lowest adit, but the ore-shoot lay about 20 ft. to the eastward of this, and was about 3 ft. in width. The intervening country is decidedly shattered, is crossed obliquely by numerous quartz veins up to 3 ft. in thickness, while the ore-body itself is broken up into a number of stringers, the whole being contained between solid walls.

The Taffy Claim was first prospected in 1897, and the auriferous leaders were rich enough to render crushing by hand in mortars profitable. A company, registered in

* A spur from the main lode appears on the creek-bank, and shows a vertical dip.

January, 1899, erected a 5-head battery worked by a water-wheel in Ten-mile Creek, about 350 ft. below the open-cut workings of the claim. In 1902 and at intervals up to the present time the claim has been let on tribute. In 1907 Curtis Bros. reopened the claim, and replaced the water-wheel at the battery with a Pelton.

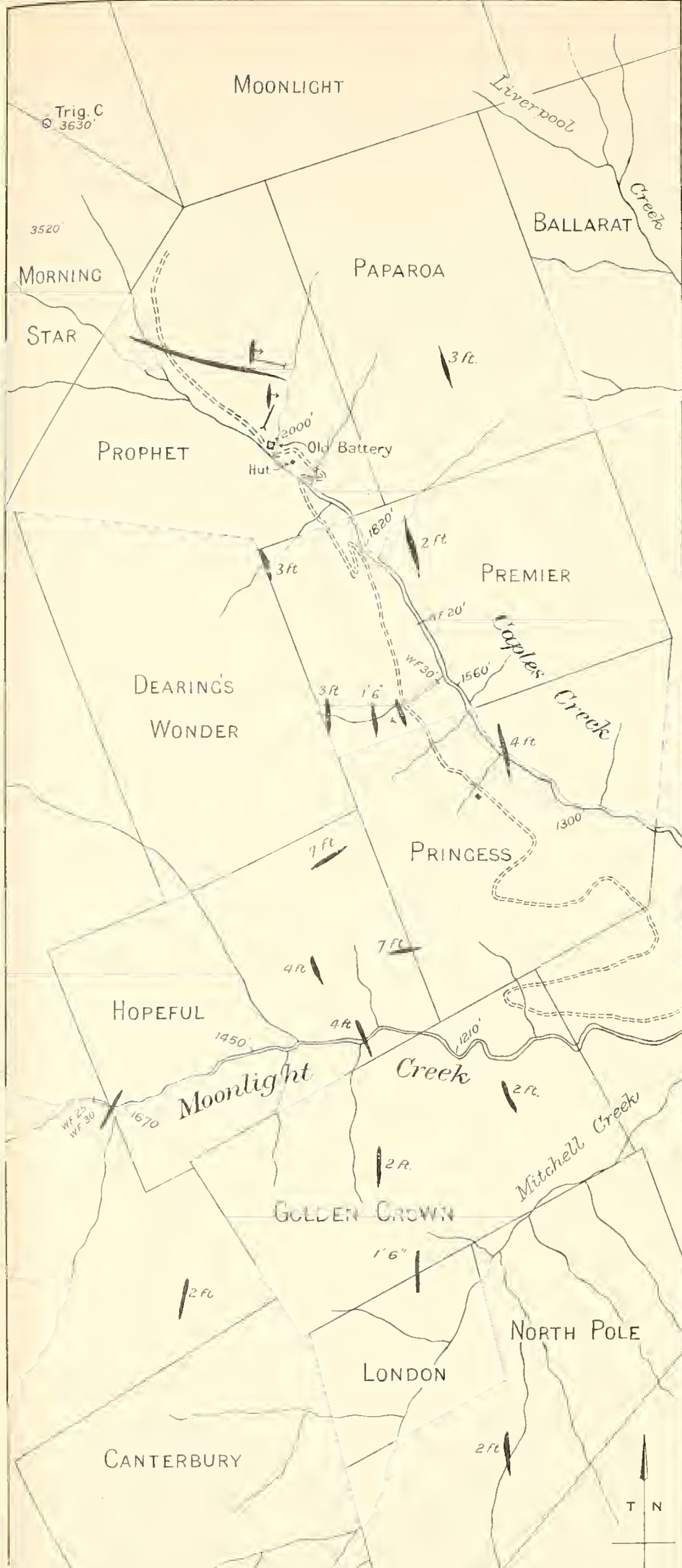
The writer had no opportunity of visiting the locality, and the following notes are supplied by P. G. Morgan or gleaned from the reports of the Inspector of Mines. The ore is extracted from an open-cut which is 2,120 ft. above sea-level, and consists of slightly altered greywacke and argillite traversed by numerous leaders and veinlets of quartz, one of which is reported to have reached a thickness of 3 ft. The whole is oxidized, and the gold is coarse and free. The stock-work is from 35 ft. to 60 ft. in width, and strikes in a north-westerly direction, and dips to the north-east. The entire mass is shattered by faulting of a later age than the quartz veins, and is completely cut off to the southward; while the writer was informed that the whole rested on a flat floor of greywacke, indicating horizontal movement of some sort. The great fracture controlling the course of the upper Ten-mile Creek is doubtless connected with the dislocations just described.

The above-mentioned claims were the only ones of the group to reach the producing stage. Other ore-shoots, however, have received attention from prospectors, and have been proved to be gold-bearing. Such are the Poneke, Sunlight, and Corrie's Reward, in the neighbourhood of the Crœsus Claim; the Homeward Bound, next the Taffy; and the Prophet and Deering's Wonder, in the basin of Moonlight Creek. In this last locality prospecting operations have been almost continuously carried out since 1907.

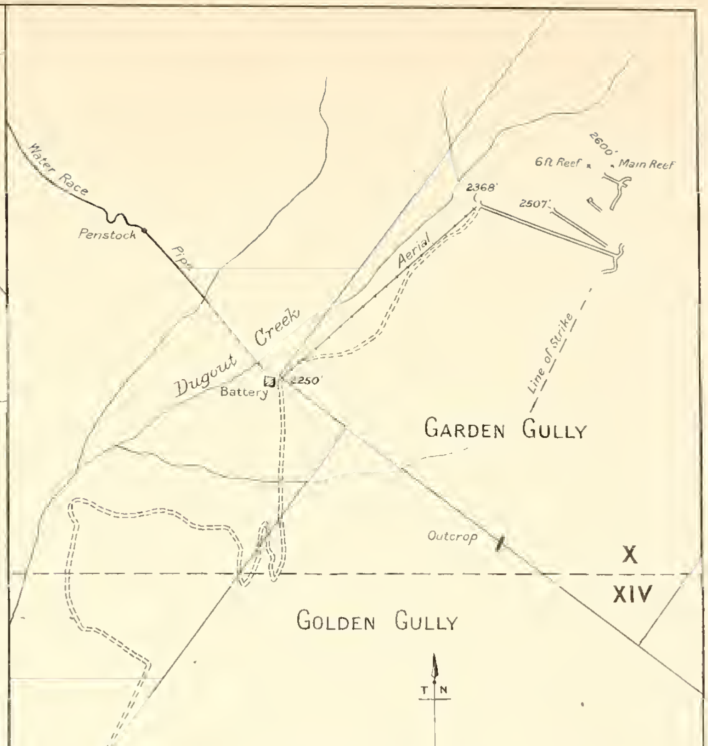
A table showing the yields from the Paparoa group of mines is to be found on page 174.

Future Prospects of Lode-mining.

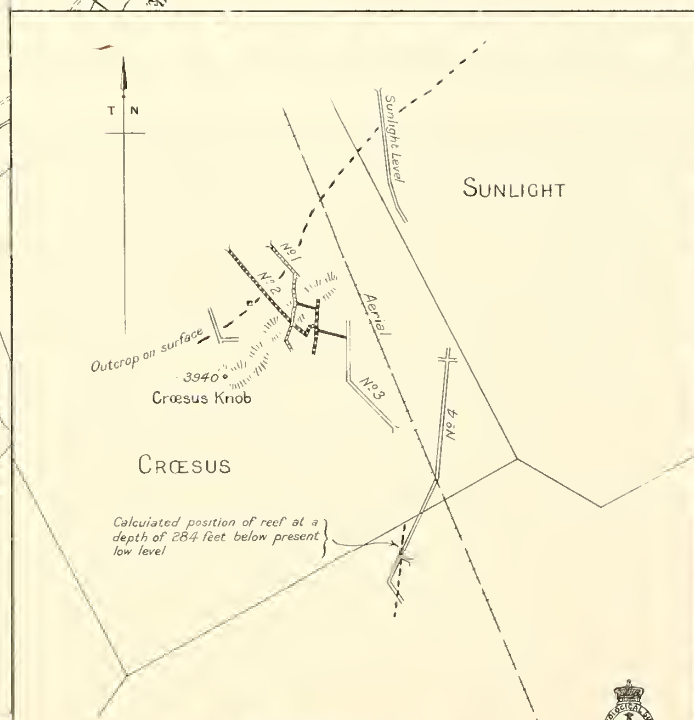
The future of lode-mining in the Reefton district depends, in the writer's opinion, on the exploitation of lodes already known. No doubt other lodes at present unknown, which are likely to yield a profit to the miner, outcrop within the subdivision, but the number of these is probably not as great as those already known. Since the discovery in 1907 of what is known as the "east reef" in the Wealth of Nations Mine through the agency of underground diamond drilling, the possibility of the existence of parallel lodes near strong fissures has been appreciated. This shoot has been followed upward to the great fault above No. 6 level. It cannot be regarded as a blind shoot—that is, a shoot that does not reach the surface—for, although its outcrop is not definitely known, probably some one of the blocks worked from the adits of the original Wealth of Nations should be referred to it. The ore-body discovered in No. 6 level south of the Blackwater Mine beyond the known limits of the main shoots conforms more nearly to the definition of a blind shoot; but in this case the fissure containing it is well known at a higher horizon, where, however, there occurred a quartz stringer, unprofitable by reason of its small size. Should this ore-body be more than a local enlargement of an attenuated stringer—should it, in fact, continue payable in depth—great possibilities are indicated. Mining men hold the opinion, based on experience, that the extent of an ore-shoot along a fissure does not vary greatly from level to level; and in conformity with this view little exploitation of a fissure is undertaken beyond the narrow limits of the shoot or shoots worked. The occurrence of blind shoots is reported from other lode-mining districts; and a definite local example would justify further exploration along fissures already followed to considerable depths, and much more crosscutting, either by drifts or diamond-drill bores, than is now



PLAN
Showing Claims and Reef Outcrops
UPPER MOONLIGHT
(BLOCK X, WAIWHERO S.D.)
Scale
CHAINS 10 5 0 10 20 30 CHAINS
FEET 1000 0 1000 FEET



PLAN OF
GARDEN GULLY MINE
(BLOCKS X & XIV, WAIWHERO S.D.)
Scale
CHAINS 10 5 0 5 10 CHAINS
FEET 0 500 1000 FEET



PLAN OF
CRŒSUS MINE.
(BLOCK XIV, WAIWHERO S.D.)
Scale
CHAINS 10 5 0 5 10 CHAINS
FEET 0 500 1000 FEET

Compiled and drawn by G. E. Harris. 1916.

undertaken. Even if blind shoots are altogether absent from the district, as is probable on theoretical grounds, too little exploratory work of this nature is carried out at the present time.

At one time or another payable returns have been obtained from more than a dozen shoots, the further exploitation of which has been prevented by their being cut off by faults. In the majority of cases the position was not understood, and the efforts made to recover the lost lodes were in consequence misdirected and futile. In some instances, two of which occurred in the Fiery Cross Mine, the dislocation of the shoots that caused or contributed to the abandonment of exploration was evidently quite inconsiderable. In such cases as the Caledonian, Golden Fleece, and Golden Treasure the difficulties of recovery do not appear to be serious. They are greater in respect to the Keep-it-Dark (east shoot), Hercules, and Cumberland, and still more is this the case in the Welcome, Kirwan's Reward, Progress, and Inkerman mines. In none of the instances does the writer regard the chances of recovery as hopeless; and the finding of the Wealth of Nations and Energetic shoots beyond fault-zones furnish examples of the solving of problems quite as difficult as any of the above. In a number of claims the post-mineral fracture seems, from the data available, to strike and dip in conformity with the lode. It is probable that in such a case the blocks of ore, although they may contain high-grade quartz, will be so small and shattered as to be unpayable, while the chances of the fault leaving the lode-fissure within a reasonable depth are not good. Examples of this structure seem to be furnished by the Painkiller shoots, Anderson's, St. George, and, to a less extent, Millerton lodes.

In the last paragraph no mention was made of the Ajax, Royal, and Keep-it-Dark (west) shoots. The two former contain high-grade ore, but the quartz bodies are so narrow that, although dividends have been paid, the operations have on the whole been barely profitable. If, however, the larger and richer Golden Fleece shoot were recovered and worked in conjunction with them, there is little doubt but that the ore from them would give a reasonable return on their proportion of the capital invested in the development of the whole series. The situation in regard to the western shoot of the Keep-it-Dark Claim is somewhat similar. Here the ore-bodies are large, and their grade varies on either side of the paying-point; and while the shoot has paid handsome dividends, two companies have exhausted their capital in working it. The discovery of the lost portion of either the Hercules or Keep-it-Dark eastern shoot, which are both of decidedly higher grade, would allow of the western shoot being worked to much greater advantage. The Golden Arch is another lode of which the ore up to the present has failed to yield a profit. The shoot, which contains high-grade ore, is at least 500 ft. long, but the vein is narrow and the walls hard. There is a possibility that by the use of hammer drills in stoping the ore could be made to yield a profit. This lode is well worth further prospecting. The surface in this locality is masked by gravels, except in the stream-valleys, so that trenching is out of the question, and the fissure has been explored only for the 500 ft. driven in the low-level adit. The southern end of the drift still shows a stringer of average size and tenor, and a like condition is reported to obtain at the northern end.

ALLUVIAL DEPOSITS.

Morgan* has divided the auriferous alluvial deposits of the Greymouth Subdivision "primarily according to age and secondarily according to character,"

* N.Z. G.S. Bull. No. 13, 1911, p. 86.

and his classification, with slight modifications, applies to the Reefton Subdivision—

I. Early Tertiary conglomerates.
II. Middle Tertiary conglomerates.
III. Late Tertiary conglomerates.
IV. Pleistocene fluviatile and fluvio-glacial gravels.
V. Recent deposits—
(*a*.) Fluviatile gravels.
(*b*.) Marine gravels and sands.

Early Tertiary Conglomerates.

These, which are considered to be of marine origin, have, as far as the writer knows, been worked for gold neither in the subdivision nor indeed anywhere on the West Coast. Prospecting, however, has proved that the precious metal occurs in these rocks in the headwater valleys of the Punakaiki and Porarari rivers, and doubtless they have contributed a quota to the gold of the recent gravels of those streams. The breccia conglomerate which shows such great development in the basin of the Freeth River also must contain detrital gold, since there is no other explanation possible for the gold of the recent alluvium in Blacksand and Kakapo creeks; and that of Slaty and Komakau creeks has certainly in part a similar origin.

Middle Tertiary Conglomerates.

That these rocks are old beach-gravels has been argued on an earlier page,* and many facts support this view. Perhaps the most striking is the association of marcasite with the gold of these deposits. It is suggested that the sulphide of iron has derived its iron from the blacksand originally contained in the beds, the sulphur having been extracted from the sulphates of percolating solutions.

The first discovery of the quartz conglomerate or "cement" here considered was in the upper portion of Murray Creek, which as early as 1868 was worked for alluvial gold. The gold in the creek-wash was quickly traced to the pyritic sandy conglomerate, in which it is stated to have occurred "like currants in a pudding." By 1870 three batteries of iron-shod wooden stamps were at work in Cement Town, as the locality was named. These machines were driven by water, of which the supply was limited, except during and immediately after rain. The writer was unable to ascertain the amount of cement crushed or the length of time over which the intermittent operations extended. Probably neither was great, the attention of investors and prospectors alike being diverted to the more promising field of lode-mining.

The auriferous conglomerate of Murray Creek has been traced into Lankey and Healey creeks, where, in both cases, they have supplied gold to the wash in the stream-beds. Other localities that undoubtedly owed the richness of their deposits to the degradation of the Miocene conglomerate are Garvey Creek and Golden Gully, a small branch of Rainy Creek. Other streams of which it can be confidently said that at least part of their detrital gold is so derived are Maori Gully, Devil, Soldier, Burke, Painkiller, Flower, and Boatman creeks. The richly auriferous wash of Garden Gully, a branch of Moonlight, must also be included. In some localities, however, where the basal conglomerates are extensively developed, the creeks draining from the rocks do not contain the colour of gold; such are Station Creek and other streams entering the Waitahu in the neighbourhood.

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* See p. 86.

Conglomerate beds have also been mined at Boatman, Lankey, and Oriental creeks, and on the hill overlooking the Progress battery. At Capleston, Boatman Creek, the mining operations were evidently quite inextensive; and as far as the writer could ascertain no crushing plant was erected, and what material was extracted was taken from small open-cuts along the steep flanks of the valley.

At Lankey Creek much more extensive operations have been undertaken. In 1879 rich gold was found on the ridge separating the two branches of the creek, at which point a powerful fault delimits the "cement," and has shattered its edge. The gold was obtained from a slope deposit entangled between great blocks of gold-bearing conglomerate. A company formed to mine and crush the conglomerate of this locality erected a 10-head battery, and began active operations in 1883. The results, however, were unsatisfactory, and the plant was soon shut down. In 1903 another systematic attempt was made to work this deposit by the Willis brothers, who erected a light 5-head battery and demonstrated its payable nature. In 1906 the claim was acquired by the brothers Bolitho, who placed a 10-head battery of heavier type on the ground, and attacked the deposit with great energy. Of recent years they have added a small air-compressing plant, and use rock-drills in their mining operations. The machinery is driven by water-power derived from a small swampy flat at the head of Lankey Creek. The conglomerate here lies on the black carbonaceous mudstones of the Devonian rocks, in which the main drives are partly driven. About 2 ft. of the overlying "cement" is removed, and the bulk of the gold is in the lower 6 in. of this. Marcasite is also present, often in considerable amount, and water-worn grains of cassiterite may be occasionally observed. Where colours of gold are seen they generally rest directly on the basal rock, and their occurrence in the quartz pebbles that form the conglomerate is exceedingly rare. The reason for the failure of the first attempt to work this deposit is probably to be found in the fact that the ore was transported to the mill by a long enclosed shoot, and during this journey many of the gold-particles became detached from the matrix and escaped through the crevices in the shoot, thus materially reducing the grade of the ore treated.

In 1911 a quartz conglomerate closely resembling that of Lankey Creek was discovered by a miner named Pulley just north of Cornish Town, on the ground held by the Progress Mines. This occurrence has been traced into the adjacent Oriental Creek, and is also known to outcrop in the head of Auld Creek. The Progress Mines vigorously developed this deposit. Two adits* have been driven, the first of which proved part of the conglomerate to have a steep dip to the eastward, while at the time of the writer's visit the lower adit had not struck its downward extension. On the Cornish Town flat the conglomerate remnant is lying on bleached greywacke with approximate horizontality. The steep dip in the same bed in the immediate neighbourhood is certainly due to faulting, and the chance of ever getting ore in the lower adit is remote. The Progress Mines stripped a portion of the "cement," made a connection with their aerial tramway, and crushed a small quantity at their mill. The results of this are not available, but presumably were not satisfactory, for operations have been suspended. In 1915 a tribute over the workings here considered was let, and a small treatment plant erected in Oriental Creek, but the best return was at the rate of only 9s. per ton, and the tribute was soon abandoned.

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* See plan of Progress Mines, p. 160.

Late Tertiary Conglomerates.

It is extremely likely that these conglomerates are auriferous, but no definite proof of this can be given, for the reason that no gold-bearing creek, as far as the writer is aware, has its basin entirely within them.

Pleistocene Deposits.

Gravels of this age have in the past yielded a certain amount of alluvial gold to the miner, but have played a far more important part in furnishing wealth to gravels rewashed from them. The deposits here considered form the "Old Man Bottom" of most miners, although a few restrict the term to the schistose conglomerate mentioned in the section immediately preceding. McKay believes, and has advanced cogent reasons in support of his belief, that these gravels occasionally contain sufficient gold to render their exploitation profitable. The great majority of the old diggers, however, consider that although the gravels indubitably contain gold, and have furnished their derivatives with the bulk of their gold-content, they themselves are of too low a grade to pay to work. The writer believes, with McKay, that operations were frequently continued in these gravels after the exhaustion of the richer overlying wash, in the belief that they formed part of a false bottom. In beds with the structure and distribution as irregular as those common to gravel-deposits, the distinguishing of an older from a newer layer is often extremely difficult. Formerly the Pleistocene gravels stretched uninterruptedly from one end of the Grey-Inangahua graben to the other. Now, however, a considerable hiatus exists, at least in the continuity of the gold-deposits, between Three-channel Flat and Coal Creek. Farther south an unbroken chain of alluvial workings, either in the old gravels themselves or in their direct derivatives, may be traced to the southern boundary of the subdivision and for many miles beyond it. These workings have been grouped according to locality, a division made for convenience only.

Three-channel Flat Group.

Some of the very earliest gold-workings on the West Coast were in Recent gravels bordering the Buller from Inangahua Junction to Lyell. Although these almost certainly derived the greater part of their gold-content from the old gravels of which the high swampy terrace known as Welshman pakihi is composed, it was not until 1880 that payable wash was discovered there by McIntosh and party, in the gravel resting on the bed-rock about 150 ft. below the top of the terrace. The overburden contained too little gold to pay to work, was too thick for stripping, and attempts to drive out the wash itself met with many difficulties. The ground contained many large stones, was very wet, and had such a tendency to run that even by working three shifts it was found difficult and dangerous to maintain the openings. No rich ground was struck, and one by one the claims had to be abandoned. These ancient deposits, however, furnished the gold of the Recent gravels worked in Welshman Creek, and probably also the greater part of that contained in the terrace remnants which at lower levels cling to the steep hillsides flanking the Buller from Pensini Creek to the junction of the Inangahua, between which points the high terrace is still in great part undestroyed.

The terraces on the right or western bank of the Buller about four miles below Lyell probably derived the bulk of their gold from the same source. In 1901 a company—the Lyell Hydraulic Sluicing Company—was formed to work these. The initial project was to bring a large race from New Creek, but this somewhat ambitious scheme was not carried out, and water was drawn from Pensini Creek. The enterprise was not successful, and in 1904 the company was reconstructed as the New Lyell

Sluicing Company. Another race at a higher level was brought in, but the returns still being unsatisfactory the claim was let on tribute, and finally the company went into liquidation in 1906. The claim and plant was purchased by Mr. A. Welsh, who formed the Old Kent Road Sluicing Company, a concern which struggled on for a few years before collapsing. The trouble in this as well as in many other instances lay in the fact that gold was decidedly more sparingly present in the main mass of the gravels than in the terrace edge, a condition due to what may be termed residual concentration.

In 1907 a claim situated 600 ft. above the Buller, on the ridge between that river and the Dee, and originally worked by Conradsen and party, came into prominence. Water was obtained from the Dee Stream, but evidently the returns were unsatisfactory, for no mention is made of the claim in the reports by the Inspector of Mines after 1908. At the time of the writer's visit in 1913 the claim had been long abandoned, and the only point learned was that it was situated in gravels indistinguishable from those classed here as Pleistocene. The old workings in Donnybrook Creek, a small branch of the Dee flowing from the south, are probably in wash which derived its gold-content from a continuation of the same gravels. As far as the writer knows there are no other workings on the eastern side of the Inangahua graben until those of Coal Creek, five miles to the southward, are reached.

In 1908 Ryan and Alborn worked a claim in Thompson Creek, of which the wash was either part of the original Pleistocene gravels or a direct derivative from them. Results could not have been satisfactory, as work was stopped in the following year.

Manuka Flat, a great terrace between the Lyell and Eight-mile creeks, at a height of nearly 1,000 ft. above the Buller, on the north side of which it is situated, is closely analogous to Welshman pakihi. All the creeks draining from this terrace have derived at least part of their wealth from its degradation. Some of them were wonderfully rich, and this at a very early date drew the attention of the diggers to the possibility of attacking this great deposit on a large scale. The magnitude of the task of bringing in water, even should the wash be found payable, deterred the individual miner, and it was not until the early "eighties" that a syndicate was formed to prospect the ground by means of adits. The results obtained were unsatisfactory, although by no means conclusive, and as far as the writer could learn no further serious attempt has been made to ascertain the value of the ground. A few old miners from time to time do a little sluicing in the concentrated gravels of the streams draining from the terrace.

Inangahua Junction Group.

The alluvial-gold workings of this group occur within the broken limestone country occupying the angle between the Buller and Inangahua rivers, and bounded on the west by the Paparoa Range. The deposits, which lie from 400 ft. to 600 ft. above the main drainage-channels, were remarkable in that they occurred within caves in the limestone. Probably the wash consisted of a reconcentration of the high-level Pleistocene gravels, remnants of which still occur in this locality. The workings were in caves along the ridge from Berlin's Bluff to Rose Mount, and the chief deposits occurred south of the headwaters of Hard Creek, and near Inangahua Junction. The auriferous gravels of the lower valleys of York, McMurray, and Fletcher creeks also belong to this group, and probably derived their gold from the same source as did the wash in the caves.

Landing Creek Group.

The Landing Creek group of alluvial workings occurs within the area that lies between Coal and Larry creeks, and that on the west is bounded by the Inangahua

River and on the east by the Brunner Range. The auriferous gravels occurring along or near the left bank of the Inangahua, from the mouth of Te Wharau River to past that of McMurray Creek, link this group with that immediately preceding. It is probable also that the gap between the groups on the eastern side of the river is bridged by a similar set of ancient gravels, in which the gold is so sparsely distributed that even when rewashed no deposits of commercial value have been formed. The neighbourhood of Landing Creek early attracted attention, the first stream prospected being known as Little or Old Landing Creek. In the " seventies " the numerous gullies and creeks appear to have maintained a community of close on a hundred diggers, while in the late years of the century many Chinese made a living in this locality. For more than ten years, however, there has been no miner resident on the field, although a little sluicing is still done at odd times by some of the Inangahua Valley settlers.

All the small creeks draining from the ancient gravels have been extensively worked, and this in spite of a most inadequate water-supply. The writer is inclined to agree with H. A. Gordon,* who examined the locality in 1894, that with an abundant water-supply much ground could be profitably sluiced.

Cronadun Group.

This important group of alluvial workings is contained in the triangle formed by Larry Creek, the Inangahua River, and the edge of the Reefton hills. In the early " seventies " the district supported a large population, and some of the operations undertaken were of a very extensive nature. This was notably the case in Redman Creek, where Lynch and party constructed a tail-race over 2,000 ft. in length. At this time great activity was also displayed at Painkiller Creek and the adjoining branches of Burke Creek. In 1879 the excellent returns from Italian Gully and Frying-pan Creek led to a revival in alluvial mining over the area here considered. In the former locality Raglan, Italian, Burk, and Coal creeks were turned over from one end to the other; and one claim dating from this period is still working. The face of wash, of typical " Old Man Bottom " appearance, is here over 150 ft. in height, of which according to the owner, Mr. Johnston Howell, the lower 16 ft. contains practically all the gold. Water is drawn from Burk and Little Boatman creeks, and the supply is sufficient only for intermittent work.

In the neighbourhood of Cronadun the small creeks draining from the high terrace cut from the Pleistocene gravels have yielded a large amount of gold. In 1890 a project was initiated to tap the main lead in the wet ground of the flat, and a tunnel was started from the bottom of the 20 ft. terrace on which the road here runs, but after driving 1,000 ft. the project was abandoned. In 1893 a second adit designed to effect the same purpose was started at a higher level, but after being produced nearly 600 ft. it broke into daylight, and no further attempt was made to work the flat until a dredge was placed on Frying-pan Creek.

In 1895 a long adit was commenced with the object of prospecting the A1 flat, an old flood-plain of Redman Creek. This was continued to about 1,500 ft. from daylight, and the wash tested by crosscuts, with unsatisfactory results. In subsequent years the A1 dredge obtained excellent returns in this locality.

In recent years, outside of Howell's claim, little sluicing has been done. In 1905-6 Whelan and party worked the ancient gravels of the terrace above Capleston with a most inadequate water-supply. In 1913 a little work was being done in the small creek joining the Waitahu about a mile below the Boatman's Short Track bridge,

* Mines Rep., 1895, C.-3, p. 109.

but these workings were not seen. There is a fair chance that the Pleistocene gravels, from which the recent wash of the streams have derived their gold, would pay to work with an abundant water-supply. The providing of this would involve a heavy expenditure; and the gravels, of which enormous quantities exist between the Waitahu and Larry Creek, ought to be carefully and systematically prospected before such a project is attempted.

Soldiers Group.

This small group of alluvial workings lies within the lower valleys of Soldier and Devil creeks, where the Pleistocene gravels and their derivatives have been extensively worked. Since 1867, when gold was first found in Soldier Creek, the wash of this small stream has been turned over at least three times. The reason for this procedure, which is most unusual in the gold-workings of the subdivision, lies in the fact that a great quantity of clay was entangled with the gravels. During the "seventies" some of the most extensive sluicing operations undertaken up to that time on the West Coast were in full swing in Devil, Darkie, and Soldier creeks, where the gravels sluiced undoubtedly belonged to the Pleistocene. Although these enterprises have been long abandoned, the great shingle-fans resulting are still a prominent feature, and until the end of the century a score or so of diggers still had their homes there. The swampy flat on which the two branches of Devil Creek unite, from its location might be expected to contain a good deal of alluvial gold, but hitherto the various attempts to find it have ended in failure. A few years ago it was bored to ascertain its value as a dredging claim, with, it is understood, hopelessly unpayable results.

Squaretown Group.

This group includes the alluvial workings of lower Slab Hut, Antonio, and Adamstown creeks, and has been named after the old township that once stood near the present Maimai Railway-station. This acted as a distributing-centre for the miners working in the area now considered, and was the last stopping-place on the road to Reefton. The most important workings were in Antonio Creek, which was prospected as early as 1867, and for many years maintained a considerable population. Most of the claims were near the forks of the stream, but old workings of quite an extensive nature are to be found from Hinau for three miles up, a narrow band of unreproductive country lying between. The workings were both on the flood-plain of the main stream and in the beds of the branch creeks. On the flood-plain and terraces the wash was from 3 ft. to 9 ft. deep, and water was so scarce that even as late as 1900 the long-tom was used for separating the gold from the gravel. In Adamstown Creek, a small stream emptying into the Mawheraiti to the south of Antonio Creek, the chief workings lie about two miles from the road. A mild "rush" occurred here about 1894; and the creek was extensively mined by European and Chinese diggers, who extracted the wash, which had an overburden of about 10 ft., the former by driving out and the latter by stripping. In the lower valley of Slab Hut Creek, which also comes within the area here under review, the terraces have been extensively mined, a work said to have been done entirely by Chinese.

Ikamatua Group.

This important set of alluvial workings is contained in the lower valleys of Blackwater and Snowy rivers, and the creeks draining into them. The streams of this locality were first prospected in 1866, and for ten years maintained a population of about five hundred. Chinese appeared about 1873, and by 1880 had almost displaced the Europeans. Practically the whole of the workings in Mossy Creek, covering an area of about 200 chains by 10 chains, as well as those on the flood-plain of Blackwater Creek, are due to them. As always, the Chinaman preferred to work on the flat, laboriously stripping the wash, which the European miner would drive out. Mossy Creek and the Snowy flats have long been deserted, but perhaps fifty diggers are still working at Blackwater—the Europeans on the terraces, the Chinese on the flood-plain.

Upland Group.

The alluvial workings hitherto considered have been in the Pleistocene gravels of the valley lowlands, and are to be found for the most part within a couple of miles of the hills. On the uplands themselves are auriferous deposits which are believed to be of approximately the same age, and it is with the workings in these that the present group is concerned. The gravels lying on the plateau-like surfaces of the hills are coarser than those of the lowlands, and sometimes have a fluvio-glacial or even morainic appearance. The bulk of the workings occur between the Inangahua and Big Grey rivers; in fact, there is only one instance, and even this is doubtful, of any sluicing having been done outside these limits on wash deriving its gold-content from the ancient gravels. The workings referred to are those of Coffee Creek, a small ravine draining into Garvey Creek from the right, which rises on a gravel-strewn hill of greywacke, from the lodes in which the gold of the wash may well have been derived. It may be stated that in addition to the localities specified below, auriferous gravel exists practically on every hill of the Reefton uplands, and every little creek or gully contains evidences of the ubiquity of the old diggers.

On Merrijigs the gravels, which crown the hill to a depth of from 80 ft. to 100 ft., have been worked from very early times. In 1882 a project was mooted to bring water from the Big River to sluice them, but this fell through, and the scanty amount to be obtained from the heads of the various small streams rising on the hill itself still forms the only supply. The claim for many years was worked by Wills and party, and is now owned by Sewell and party, who express themselves as satisfied with the returns obtained. Maori Gully and the upper valley of Slab Hut Creek have been very extensively worked. It was the prospector Edward Carton who first proved the value of the wash in this locality, his discovery being made in 1878 on Carton's Terrace, overlooking the stream to which the writer has given his name. Much of the ground here was very shallow and readily worked, but nevertheless for many years highly remunerative returns were obtained, the bulk of the miners being Chinese.

The discovery in 1906 of the Birthday reef in the upper valley of the Blackwater led to a revival of prospecting in this locality. It was soon found that a great amount of alluvial ground existed, and good wages were made for a time by a considerable number of miners. The number of large boulders contained in the wash, and the inadequacy of the water-supplies, have brought about the abandonment of most of the claims, and in 1914 only White's was being worked.

Granville Group.

The workings of this group are within and south of the great bend of the Grey River, and extend beyond the boundary of the subdivision to Napoleon Hill, which lies about two miles southward. On its flanks Mosquito, Noble, Half-ounce, and Orwell creeks, all richly auriferous, have their sources. In this group may also be included the inextensive workings on Maiden Creek, a branch of Craigieburn, which enters the Grey from the west opposite Totara Flat. From the circumstance that the first " rush " was a " duffer," the main stream, which subsequent work proved one of the best on the West Coast, owes its name. The locality was prospected in 1866, and for nearly ten years supported a population of from five hundred to eight hundred diggers. By 1875 much of the easily worked ground had been exhausted, and the miners were directing their attention to the creek-beds, which by the aid of water-wheels and pumps were successfully worked. Then came the "rush" to Kumara, which drained the district of many of its most energetic members, some of whom, however, returned in a few years. Gradually the claims were worked out, while the exploitation of others was checked by the accumulation of tailings. The population diminished, until in the early "nineties" only a hundred and fifty remained, while in 1914 the old townships of Nobles and Granville were all but deserted.

In the Waipuna basin the bulk of the very extensive workings are in Mosquito and Noble creeks, where terraces about 100 ft. above the stream-levels have yielded the principal returns. The main stream below the junction of these creeks was too gorgy to work, and hence in 1888 a tunnel, designed to divert the stream, was started from the Big Grey, but unfortunately was driven at too high a level to effect this purpose.

In 1891 the Duffer's Creek Gold-mining Company started to work the flat of the creek of that name, much of which had been hitherto untouched owing to the lack of fall for the tailings. The method adopted was to sluice the gravels into a well, from which the larger stones were lifted 70 ft. by a bucket elevator, while the water and finer material were carried off through an underground tail-race. Some of the ground worked had already been driven out, nevertheless the company were fairly successful for several years.

In 1895 a scheme for bringing in water from Randall Creek, a tributary of the Ahaura, or alternately from Haines Creek, a branch of Allen Water, which itself flows to the Big Grey, was mooted. A survey was made, but the almost complete failure, from a commercial point of view, of the Nelson Creek race no doubt prevented this enterprise being carried further.

In the early years of the century several dredges were built to work the stream-beds of this locality, but none was financially successful. After the failure of the Sullivan's Lead dredge Baybutt and party took up the claim, and, having acquired enough minor water-rights to ensure a fair water-supply, have up to the present obtained most satisfactory results.

Moonlight Group.

This group, on the western bank of the Grey, includes nearly all the alluvial workings that occur along the base of the Paparoa Range from Komakau Creek to the southern boundary of the subdivision. They penetrate into the mountains along Moonlight Creek; and as ancient gravels are here extensively developed, the workings, although they yielded gold of a coarse hackly nature, have been included with those deriving their gold from Pleistocene deposits. For many years this locality was one of the most prosperous alluvial-mining centres on the West Coast, and a little work is still going on in Moonlight, Shellback, and Garden Gully creeks, while at Healy Gully, just without the subdivision, a large sluicing claim was in active operation when visited in 1913.

The first discovery of gold in this district lies to the credit of George Moonlight, and was made early in 1866. The population was maintained for many years, mild "rushes" taking place to Shellback Creek in 1888, to Garden Gully in 1890, and to Stewart and Dougall terraces, in the same locality, in 1892.

The Republic Sluicing Company in 1898 started work at Healy Gully, where sluicing in a small way had already been in progress for about twenty years. A race, the construction of which was subsidized by the Government, supplied water from the Roaring Meg to several small private claims, as well as to the claim of the parent company. Operations were fairly successful until 1906, when the claim was let on tribute. Slips on the race gave a great deal of trouble, and the claim was finally taken over by T. Jones and party, who were energetically working it during 1913.

In 1900 a scheme for the bringing-in of water for the sluicing of Shetland Terrace, under which name the pakihi lying between Moonlight and Garden Gully creeks is known, was mooted. A company was formed, and a race surveyed to tap the head of Moonlight Creek. This proved too great an undertaking for the finances of the company, and the race stopped at Fenton Creek. Sluicing was commenced in 1903, but the water-supply (from Fenton Creek) proved inadequate, and the returns were not satisfactory. In 1906 a reconstruction took place; a siphon was placed across the main Moonlight gorge, and the water from Liverpool Creek used. The results were still unsatisfactory, and the company closed down in 1909.

Blackball Group.

That portion of the basin of Blackball Creek within the subdivision contains high-level terraces corresponding with Shetland, Stewart, and Dougall terraces of the Moonlight basin. Similarly the ancient gravels of the lowlands worked at Montgomerie Terrace and Ford Creek correspond with the gravels from which the gold of Shellback, Caledonian, and Baxter creeks was derived. Upper Blackball was prospected very early in the history of the Coast, and several large nuggets were there discovered, but the population at no time seems to have been more than forty. In 1886 the prospects of the Minerva Company looked bright. A tunnel was driven through the saddle at the head of the creek, by which the Roaring Meg could be diverted; a race giving an ample supply of water was constructed, and sluicing commenced. The ground was from 50 ft. to 100 ft. in depth, of which perhaps the lower 20 ft. was payably auriferous. More than half the deposit, however, consisted of enormous boulders up to 40 tons in weight, which had to be broken up by blasting. The company was reconstructed as the Roaring Meg Sluicing Company in 1897, of which Mr. G. Perotti, of Greymouth, held a controlling interest. Work continued with many interruptions till 1906, the claim during part of this time being let on tribute. A few miners still work on the terraces and, during dry weather, in the creek-bed, but otherwise the place is deserted.

Recent Auriferous Deposits not clearly derived from Older Alluvium.

Fluviatile Gravels.

The bulk of the alluvial workings hitherto considered have been in gravels of Recent age. These have, however, so obviously derived their wealth, in great part, from older sedimentary deposits that it was deemed advisable not to separate them. Under the present section will be considered only those Recent fluviatile deposits that have not already been mentioned.

At Old Diggings, near Berlin's, the principal workings are on the north bank of the river, and only a small portion of the auriferous ground occurs within the Reefton Subdivision. Perhaps the largest concern that ever operated here was the Wellington Gold-mining Company. Their claim was situated just within the subdivision, and the wash consisted of the Recent gravels of the 80 ft. erosion period. Sluicing commenced in 1899, the water being drawn from Lake Rahui. Returns were unsatisfactory, and after struggling along for a few years, during which for a part of the time the claim was let on tribute, the company in 1903 went into liquidation.

There is a small group of workings near the lower forks of Larry Creek, which extend along the valleys of Bateman and Drysdale creeks until these become too gorgy to be sluiced. These workings were deserted even in 1882 when McKay* visited this locality. Only the creek-beds and the lowest terraces have been worked, and the wash must have derived its gold-content directly from the lodes that are here known to traverse the greywackes. It may be pointed out that payable auriferous quartz was not discovered in this locality till 1896, after the very existence of these alluvial diggings had been almost forgotten.

The beaches of the Big Grey between the Clarke and Alexander streams have been worked for gold with fair success. Not a colour can be obtained in the gravels of the main river above the confluence of the latter stream, and it is a fair inference that what gold exists in this locality has come down the Alexander. The lower course of this stream is so gorgy, and its upper so torrential, as to render its bed unworkable. Quartz lodes were observed in Absalom Creek, and from time to time prospecting parties explore this district. Nothing of value has ever been found; and the heavy veneer of gravels which obscures all outcrops save in the larger stream-beds renders the chance of finding lodes well nigh hopeless.

Marine Gravels.

The occurrence and distribution of the beach gravels and sands belonging to the four most prominent strand-lines have already been sufficiently indicated on earlier pages. All these deposits contain blacksand and gold to a greater or less degree, and all have received attention from the alluvial miner.

Charleston was prospected in 1866, and shortly afterwards the Brighton Beach leads and the old marine sands to the southward were discovered. The strip of beach between Brighton and St. Kilda, and the wave-cut terraces backing it, were exceptionally remunerative, and many small fortunes were made. It was probably the discoveries at Charleston and Brighton that induced the diggers from Greymouth to try their luck along the beach northward; at any rate, the Seventeen-mile Beach was prospected at about the same time as Brighton. The discoveries here, however, were not nearly so encouraging as farther north, and for many years the bulk of the mining was carried on between the tide-marks only. In September, 1879, R. H. Wessels discovered a rich lead, afterwards known as the Barrytown lead, along the base of the mountains about a mile from the shore. The difficulties of transport were very great, and it may be for this reason that this field was not worked out as quickly as many others. Within late years practically the only gold-workings carried on in the coastal region of the subdivision are those of the hydraulic elevating claim at Barrytown, and even beach-combing has almost ceased.

The marine gravels of the 500 ft. strand-line in the Reefton Subdivision have received little attention. This is due to the facts that they are now greatly denuded, and lie at a height to which it is difficult to bring an efficient supply of water, rather than to their lack of gold. Gravels of this strand-line have been prospected on the ridge between Deverey and Canoe creeks, on the track over the Gentle Annie Rocks, and again in the basin of the Four-mile Creek. In the Buller-Mokihinui Subdivision the gravels here considered are much more generously developed, and have been worked to a considerable extent in the Charleston district.

The gravels and sands of the 200 ft. strand-line have in the past been of great commercial importance on the West Coast, having furnished a great amount of alluvial gold in the Buller-Mokihinui, Reefton, and Greymouth subdivisions. Welsh-

* Verbal communication.

man Terrace at Brighton, and its northern continuation, Kelly Terrace near St. Kilda, belong here, as do certain relatively unimportant and ill-defined terraces between the Fox River and the Gentle Annie Rocks. From the Punakaiki southward past Barrytown these deposits have been extensively worked, the lead being cut up by numerous small creeks into what are known as terraces. From north to south these are Blue Jacket, Albion, Scotchman, Hibernian, Tipperary, Parnell, Niagara, von Moltke, Buckley, Wilson, Geordie, Canoe Creek, Morgan, McIlroy, Barry, Kumara, and Brunnerton terraces. Of these Canoe Creek was worked years before any of the others. In many of these the wash was driven out, although ground-sluicing appears to have been the favourite method of exploitation. Light crushing batteries were occasionally used, as at the von Moltke Terrace in 1905.

In 1897 the Waiwhero Sluicing Company began operations at Buckley Terrace, where the wash, lying at a height of 250 ft. above sea-level, was from 12 ft. to 30 ft. thick, under a cover of from 5 ft. to 25 ft. of barren gravel. The ultimate chief water-supply was intended to be obtained from Canoe Creek, but at this time sluicing was carried on intermittently by means of water from several small streams. The company was much hampered by litigation, and by the difficulties met with in completing its main water-race across the fault-zone occurring about four miles from the mouth of Canoe Creek. A reconstruction took place in 1899, the new company being known as the Waiwhero Sluicing and Dredging Company, the intention being to sluice the wash on Buckley Terrace and place a dredge on a claim near the mouth of Canoe Creek. The main race, six and a half miles long, was completed in 1901, and provided water at Buckley Terrace and the beach claim under heads of 400 ft. and 600 ft. respectively. The dredging scheme was abandoned, and a face opened for hydraulic sluicing and elevating on the beach claim, where the wash was found to be 70 ft. in depth. Sluicing was steadily prosecuted, and was for a time profitable. In 1905, however, the claim and plant were purchased by Mr. Andrew McKay, who worked the beach claim with fair success for several years.

The gravels and sands of the 80 ft. and recent strand-lines have been worked from the earliest times, and their annual yield, though now greatly reduced, is still considerable. In the old days it was the numerous diggers scattered along the shore, but chiefly on the Seventeen-mile and Brighton beaches, who maintained the output, while at present and for the past fifteen years the hydraulic elevating claims have been the chief producers.

The first of these claims to be worked was owned by the Barrytown Flat Gold-mining Company, and is situated on the coastal plain north of Baker Creek. Operations were commenced in 1896, and a race giving 600 ft. of fall was brought in from Baker Creek. Sluicing started in 1898, but the returns were barely payable, and the claim was taken over by Messrs. White and McKay in 1899. These gentlemen increased the spread of the gold-saving tables from 300 square feet to 800 square feet, and brought in water from Fagin Creek. The claim is still working, and yielding profitable returns. The wash at present dealt with is about 12 ft. thick, and consists of quartz sand containing numerous layers of blacksand and occasional pebble-bands, the whole overlain by a layer of recent peat. The sand is broken down by hydraulic power, and elevated in the usual manner about 65 ft. before being distributed over the tables.

In 1897 the Barrytown Flat No. 2 Company was formed to work a beach claim about three miles north of that just described. The wash was here 25 ft. deep, and the claim was worked by water drawn from Canoe Creek. Operations were not profitable, however, and the claim was abandoned in 1900.

Another equally unfortunate venture was undertaken by the Pactolus Sluicing Company. The claim extended about a mile along the narrow coastal plain southward from the Fourteen-mile Bluff. Water was drawn from the Twelve-mile and Fourteen-mile creeks, the race from the Twelve-mile being two miles long and giving 400 ft. of fall, while that from the Fourteen-mile Creek was a quarter of a mile long and gave 500 ft. of pressure. Sluicing was commenced late in 1899, and ceased in June, 1900, the ground being found unpayable.

All these companies had great difficulties to overcome, the most pressing of which were the supplies of timber and piping. It might be thought that no trouble would be experienced in obtaining suitable timber, but the trees growing on the coastal plain and range-front are small and twisted, and do not furnish planking suitable for fluming. McKay and White have a small sawmill in connection with their claim, but the great bulk of the timber used by the above-mentioned companies had to be rafted from Greymouth. The pipes also had to make this hazardous journey, since the only road connecting Barrytown with Greymouth is in part across a loose gravel beach, through which heavy loads can be dragged only with the greatest difficulty. The constructing of the races proved very costly, owing to the steepness of the spurs not having permitted the accumulation of clay and gravel, and it was found necessary to cut benches in the sidelings on which to rest the fluming to carry the water. Another difficulty lay in saving the gold, which, like that of all marine placers, is very fine, but this was overcome by greatly increasing the spread of the gold-saving tables.

The Source of the Alluvial Gold.

The writer in the preceding pages has endeavoured to bring out the fact that as far as the Reefton Subdivision is concerned the gold of the Recent gravels, which have furnished much the greater part of the alluvial gold so far won, has had its immediate source in the deposits of Pleistocene age. These in turn derived their wealth from the basal beds of the Miocene and from the lodes. The ultimate source of all the detrital gold is, of course, the lodes traversing the Palæozoic sediments. The data available do not permit of even the roughest apportioning of the amount of gold furnished to the Pleistocene gravels respectively by the Miocene conglomerates and the quartz veins. This, however, is not a vital point in the discussion that follows, since the Tertiary conglomerate beds were laid down on a sinking shore, and it is extremely improbable that the gold they contain had travelled far from its point of origin. This is confirmed by the fact that the Miocene deposits are richly auriferous only where adjacent to lode-bearing areas, and where resting on granite or gneiss have given rise to gravels that carry no trace of gold. In the Reefton Subdivision a similar condition obtains in respect to the Pleistocene deposits. Gravels of this age extend right across the Grey-Inangahua graben, but it is only where they abut against the Aorere rocks and the Miocene conglomerates, where these latter overlie, that the rewash from them has been rich enough to work. As the distance from the older rocks increases, so does the extent of the alluvial workings—that presumably are in proportion to the amount of payable wash—decrease. This is well seen near Reefton, where the workings farthest from the Palæozoic rocks are those close to the railway-tunnel; westward of this inextensive alluvial patch prospectors report only an occasional colour in the creeks draining the great mass of Old Man gravels of this locality. And so it is throughout the subdivision, the Pleistocene gravels and the wash from them are rich in gold only when the former have derived their material from Aorere rocks or from Tertiary conglomerates in close proximity to Aorere rocks. Thus along the eastern side of the graben gold-workings are entirely absent northward from the Freeth River to Inangahua Junction, and a like condition prevails on the eastern side between Coal Creek and the Dee Stream. On the other hand, southward from the Freeth River and Coal Creek are to be found unbroken chains of workings that extend far beyond the limits of the subdivision. Similarly, the workings of Welshman pakihi and the neighbourhood are in close proximity to the lode-area of New and Lyell creeks. It is impossible to account for these facts of distribution on the ground of coincidence; and the conclusion is inevitable that the alluvial gold of the Reefton Subdivision, whether contained in the Tertiary conglomerate beds, Pleistocene or Recent gravels, has been derived from the lode-areas now exposed at the surface.

As various writers have pointed out, the main lead of alluvial gold on the West Coast continues in a nearly unbroken curve from north of Reefton to Ross, a distance in all of ninety miles. Along it occur mining townships, of which the names are household words to such of the old diggers as still remain. In the Reefton Subdivision there are two meridionally disposed major leads, separated by zones of barren ground of variable width. The western starts at Coal Creek, follows the edge of the slates and greywackes till Slab Hut Creek is reached, south of which it leaves the old rocks, and may be traced by the workings in the lower valley of Antonio Creek and by those in Adamstown, Mossy, and Duffer creeks. The second lead, which may be said to begin on Merrijigs Hill, continues as a broad belt through Maori Gully and the upper valleys of Slab Hut and Sawyer creeks into the basin of the Big River, where Cariboo and numerous other small creeks have been worked; thence into Blackwater Creek, the Snowy River, and across the Big Grey to Napoleon Hill. This lead first touches the lowlands near the forks of Antonio Creek, but as the workings are followed southward they gradually encroach more and more on the gravels filling the graben. Each of the two major leads described is made up of minor leads, which, as far as can be ascertained, preserve a general parallelism with the disposition of the main lead.

It has been stated on a preceding page that the Pleistocene gravels occupy the floor of an ancient valley, the infilling of which was brought about by regional depression. Much of the material used by the streams in their work of aggradation is believed to have been of glacial origin, and the gravels contain a considerable amount of clay and sand. Owing to the depression of the land and the vast amount of spoil available, deposition was very rapid, and, once the waste reached the rift-valley in which the river was aggrading, little opportunity was afforded the streams for assorting it or concentrating the gold. Thus the lower portions of the gravels as a whole contain gold to a very small extent, although close to lode-containing areas of rock the amount may be of commercial importance. As the rivers became graded the sorting of the spoil from the hills was more efficiently performed, a concentration of gold took place along the beds of the streams, and where conditions were peculiarly favourable workable gold-deposits were formed. It is believed that the main gold-lead of the West Coast marks the position of the bed of the Pleistocene river on its aggraded plain. The two parallel leads of the Reefton Subdivision were produced either by an alteration of the course or by the branching of the main stream.

McKay, in a report entitled "Geological Explorations of the Northern Part of Westland,"* elaborates a thesis first suggested by Hector,† that the Old Man Bottom gravels of the West Coast and the Moutere gravels of the Nelson district were deposited by a great river that, rising in mountains lying to the westward of Hokitika, flowed north-eastward and discharged into Blind Bay. Gravels occur only

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* Mines Rep., C.–3, 1893, pp. 132–86, especially p. 174.
† Prog. Rep. of the G.S. of N.Z. during 1866–67, 1867, p. 13.

in the upper and lower portions of this hypothetical valley, its central portion now being occupied by a series of mountain-ranges that are traversed by no valley-system. It is true that a remarkable north-east-trending depression, first noted by von Haast,* crosses these mountains; but this, which is quite narrow, bears not the faintest resemblance to any part of a great valley-system, and is, moreover, primarily of structural and not of erosional origin.† McKay was well aware of the difficulties attending the adoption of this hypothesis, and does not minimize them. The writer has no intention of discussing this subject. His views concerning the structural, geological, and physiographical features of the subdivision have already been set forth, and are regarded as sufficient disproof of the above-mentioned hypothesis. Indeed, the theory seems to have suggested itself to McKay because of the impossibility of deriving the alluvial gold of North Westland from the Alpine chain. There can be no doubt that the lode-bearing areas lying respectively at the northern end and on either side of the Inangahua-Grey rift-valley are competent sources of supply for all the auriferous alluvium contained within the area described. The gold in the leads southward of the Reefton Subdivision is believed to have been derived chiefly from the same sources, although other small areas of lode-bearing rocks have locally greatly enriched the gravels. The marine deposits of the coast-front obtained their wealth from the detrital gold carried to the sea by the streams to the southward, and transported by the waves northward along the coast.

Gold-dredging.

Dredging in the Reefton Subdivision will be considered under four locality groups—viz., the middle Buller, the Boatman Creek, the Mawheraiti, and the Grey valley groups. Dredges may be divided into river and paddock dredges, according as the water in which they float constitutes part of the main stream of a river or occupies a paddock or lagoon excavated by the dredge itself from an alluvial flat. It is obvious that this distinction must not be too closely pressed, as during work a dredge may excavate a paddock in a river-flat, and may be entirely cut off by the accumulation of its own tailings from the stream in which it started operations. Again, dredges may be divided into elevator and sluice-box dredges, a classification based on the mode of disposal of tailings adopted by the designer.

Historical Account.

Middle Buller Valley Group‡—The first bucket-dredge to operate in the Reefton Subdivision was built in 1891 by the Whitecliffs Company (registered 19th June, 1890) near Berlin's. Dredging was then in its infancy, and it is little wonder that the dredge failed to pay expenses. In 1892, after a few months run, it was stranded owing to a flood; and the company, disheartened by failure, sold it to Smith and party for the paltry sum of £40. The dredge was raised and renamed the Cocksparrow, and a start was made at the same place where the company had obtained little or no result. The returns were favourable, expenses and more than wages being paid. Since it was believed that better ground existed farther up the Buller, the dredge was removed to above the junction of the Inangahua. Returns continued payable, and the Cocksparrow Dredging Company was registered on the 28th April, 1894. Till 1897 the dredge was constantly at work, winning nearly £10,000 worth of gold, but paying only £525 in dividends. The river-beaches from Inangahua Junction to a mile beyond

* Haast, J. von.: Rep. of a Top. and Geol. Explor. of the West Districts of the Nelson Prov. N.Z., 1861, p. 70.

† N.Z. G.S. Bull. No. 6, 1908, p. 72. ‡ See also N.Z. G.S. Bull. No. 17, 1915, pp. 27, 28.

the Dee were worked with varying results, but, as a whole, operations cannot be said to have been successful, and in 1897 the dredge was sold for £1,000 to a working-party, and rechristened the Exchange. Under the new name considerable success was achieved, and in 1898 the machine was acquired for £2,000 by a syndicate, which, no doubt aided by the success of the Otago dredges, were able to dispose of claim and dredge to the Consolidated Company (registered 18th January, 1899). The dredge received an extensive overhaul, but the returns were unsatisfactory, and in the beginning of 1901 the company was wound up and the machine disposed of to the Old Diggings Gold-dredging Company, the possessors of a claim below Berlin's. The dredge was old and out of date, and the new owners had great trouble owing to frequent breakdowns and consequent loss of time. Although the ground was good the results were unprofitable, and in 1903 the dredge was sold to Hansen and party, and the company liquidated. For a couple of years the returns were satisfactory, after which the old trouble of breakdowns caused the final abandonment of the dredge in 1905.

The Mokoia dredge, owned by the Mokoia Gold-dredging Company (registered 21st October, 1899), started work on the 13th October, 1900, on a claim about a mile above Three-channel Flat. The dredge had only been at work a few days when a heavy flood carried it a considerable distance down the river, leaving it high and dry on a beach. It was three months before a start could again be made; but after this misfortune work was steadily carried on for three years, generally with fair and sometimes with excellent results, enabling dividends to the extent of nearly £2,000 to be paid. The next three years were poor and unprofitable, and in 1906 the dredge was bought by De Filippi and party, who worked it with satisfactory results until the end of 1907, when they sold it to a Greymouth syndicate. The dredge, as the New Mokoia, was shifted to opposite Flaxbush Creek, and until 1909 worked with fair results. In 1910 returns were unsatisfactory, and in 1911 the dredge was dismantled.

The Buller Junction Gold-dredging Company was registered on the 6th June, 1899, and the dredge was completed on the 28th January, 1901. Work was commenced in the Buller River about 20 chains above the junction of the Inangahua, and the returns were profitable for more than three years, enabling £3,437 10s. to be distributed in dividends. This dredge obtained in one week, during 1902, 234 oz., the record return for the Buller River. The returns during 1904 were poor, and the company went into liquidation in December of that year, the dredge being sold. Shortly afterwards a flood carried it four miles down the river, and at a point about a mile below Whitecliffs the new owners, Smeaton and party, began work. For six years work continued, the dredge being shifted to Inangahua Junction and back again to Rocklands. Early in 1913 work ceased, and the dredge was dismantled. Mr. T. Hubert Lee, of Reefton, the secretary of the syndicate, informed the writer that the returns barely recouped the party on their outlay.

The Rocklands Beach Gold-dredging Company was registered on the 1st September, 1899, but did not start work until late in 1901. Much time was lost owing to frequent breakdowns; returns were never more than moderate, and no dividends were paid. In 1905 the company went into liquidation, and the dredge was sold. From 1906 to 1912 the dredge was worked near Berlin's with fair results by Harrison and Gilstrom. Early in 1913 returns became unsatisfactory, and the dredge was dismantled.

The Premier Gold-dredging Company was registered on the 9th March, 1900, and work was commenced early in December, 1901, on the claim below Inangahua Junction. Returns were moderate, enabling one small dividend to be paid. In 1904 the company was wound up and the dredge sold to Hansen and Dellavedova, who moved it with great difficulty to Three-channel Flat. During 1905–6 the dredge was worked with fair results, although much time was lost through breakdowns. Work was finally stopped toward the end of 1906, and the dredge dismantled.

The Welcome Gold-dredging Company was registered on the 5th May, 1900, and the dredge was finished early in December, 1901. During 1902 returns were moderately profitable, but later results were so poor that the company went into liquidation, and the dredge was sold in 1904 and dismantled. The claim was about a mile and a half below Inangahua Junction.

Feddersen's Gold-dredging Company was registered on the 5th March, 1901, and the dredge started operations on the 28th December, 1902, near the lower end of the claim at the great bend of the Buller below Lyell. Work was continued for a few months, but the results being unpayable the dredge was shut down. Soon after it was left high and dry by a flood, and remained stranded for nearly a year. In June, 1904, the dredge was shifted to the mouth of New Creek, and paid dividends to its owners, the New Feddersen's Gold-dredging Company (registered 1st August, 1904). During 1905–6 returns were moderate only, and in 1907 the company went into liquidation.

Boatman Creek Group.—The first dredge in the basin of Boatman Creek was built by the Reeves Proprietary Gold-dredging Company (registered 19th October, 1899), and commenced work in November, 1900. The ground was payable, and a dividend was declared in 1901; but in later years frequent breakages, due primarily to the fact that the dredge was too light for the ground, made returns barely balance expenses. In 1903 the machine was strengthened, and another dredge, the Merrimac, brought from the Kawarau in Otago, was re-erected on the claim. The results obtained, however, were still disappointing, and in 1906 the company was wound up and the plant and freehold claim sold to Messrs. Hessey, Cameron, and Tacon. Under the new management the Merrimac was repaired and remodelled, and work was started again in the beginning of 1908. Returns were consistently and highly remunerative till June of 1913, when the dredge sank while at work. Efforts at raising ended in failure, and it became a total wreck. Another machine is now in course of erection, and will, it is expected, soon be in commission.

The A1 Gold-dredging Company (registered 13th November, 1899) began active work on the 6th June, 1901, on Redman Creek, a branch of Boatman Creek. Very fair returns were obtained, and for three years dividends were paid. In 1904 it was found necessary to renew the pontoons, which were in a very bad state. Later returns were unsatisfactory, and in 1906, after being run at a loss for several months, the dredge was sold to a working-party, and the company went into liquidation. The dredge continued at work almost constantly with moderate results until 1909, when, the returns becoming poorer, it was dismantled.

The Boatman's Creek Gold-dredging Company (registered 28th August, 1902) started work late in 1903 in Boatman Creek, near the junction of Burk Creek. The returns obtained by the company were unsatisfactory, and the dredge was let on tribute. In 1905 it sank, but was afterwards raised and worked by Coghlan and party near the junction of Redman Creek. Only moderate results were obtained, and in 1910 the dredge was sold, dismantled, and removed to Coromandel.

In 1910 a dredge was built in Frying-pan Creek near Cronadun. The intention was to work Frying-pan Flat and the valleys of several small streams discharging into the creek to as far as Due North Creek. Returns, never more than moderate, became poorer in 1913, and the dredge was shut down in 1914.

Mawheraiti Group.—Dredging in the Mawheraiti basin has been more successful than in other parts of the subdivision. A dredge built by the Greymouth Lagoons Gold-dredging Company began work in August of 1902 in Red Jack Creek, a small branch of the Blackwater River, but owing to the patchy nature of the ground and a variety of other causes, of which breakdowns and lack of water were the chief, it barely paid working-expenses. In 1904 it was acquired by the Ikamatua Gold-dredging Syndicate, but no better success was achieved. In 1907 the Worksop Company purchased the dredge and re-erected it on Antonio Creek.

The Blackwater River Gold-dredging Company, registered on the 27th April, 1900, did not complete its dredge until the end of January, 1903. Handsome returns have been won, and over £12,000 paid in dividends. Just after Christmas, 1913, the dredge sank at its moorings, but has since been raised and again put into commission.

The Slab Hut dredge was originally the Kangaroo Creek dredge, which was removed to the neighbourhood of Tawhai Railway-station and recommissioned towards the end of 1904. Till 1908 returns were consistently payable, but after this the heavy wash strained the machinery to such an extent that breakdowns became frequent. The company went into liquidation in 1909, and sold the dredge to a private syndicate. Subsequently the claim was worked intermittently by various owners, without much success. In 1914 a strong syndicate, of which Messrs. Hessey and Cameron are members, acquired the dredge, overhauled the machinery, fitted larger buckets, and installed a new boiler. This enterprise quickly demonstrated that the wash, when attacked by a sufficiently powerful dredge, was highly payable.

Antonio Creek dredge started in January, 1907, near the head of Antonio's Flat. The claim had been bored before the building of the dredge, and the results were considered satisfactory. Nevertheless the returns as a whole were unpayable, and in 1908 the dredge was taken over by the mortgagees, who, after working the claim with no better result for a few months, sold it for re-erection at Frying-pan Flat. The difficulty in this case was the trees which had been felled by the early diggers, and subsequently covered over by the tailings from their claims on the terraces.

The Worksop Gold-dredging Company (registered 20th March, 1907) had its dredge in commission by the beginning of 1908. Operations began in Antonio Creek at a point about a mile and a half above the junction with the Mawheraiti, and have been extended for some distance into and along the flats of this latter stream. From the start this dredge has been a conspicuous success, and, although expensive to run (costing from £100 to £120 per week), had yielded such returns as permitted the distribution of £41,850 in dividends by the end of 1914. The company has taken up a further area in addition to its original holdings, and is building a second dredge.

The Murray's Freehold Gold-dredging Company is working on its own freehold in the Mawheraiti valley, near the debouchure of Antonio Creek. Dredging began early in 1915, and for several months the returns were inadequate. At length, however, the Worksop lead was reached, and the yields have since been satisfactory.

Grey Valley Group.—Dredging in that portion of the Grey valley lying within the Reefton Subdivision has been a dismal failure. Of the twelve dredges built, only one paid back part of the capital expended, and of those sold to working-parties for small sums it is doubtful if any repaid their purchasers. As early as 1898 the project of placing a dredge on the main river at the Little Grey Junction was seriously considered, and eventually four dredges were built on that portion of the river between the Waipuna and Moonlight creeks. These were the Waipuna and the Grey River Consolidated, completed in June of 1900 and 1901 respectively, and the Golden Lead and the Caledonia, both finished in December, 1901. All quickly demonstrated that the gravels of the Grey in this part of its course could not be treated by dredges at a profit, and the companies owning them soon went into liquidation.

The dredges working in branch streams were more successful. The Mosquito, built on a small branch of the Waipuna, and completed in December, 1901, yielded good returns at once, and was a consistent gold-producer until 1904, when the claim was exhausted. Mosquito No. 2 started work in 1903, but the amount of buried timber in the claim caused so much loss of time that the returns were unsatisfactory. Both companies were wound up in 1905, and the dredges passed into the hands of working-parties. Returns, however, were only moderate, and the dredges were finally dismantled.

Three dredges were placed in Duffer Creek basin, of which the first to be commissioned was the Totara Flat, built on Brandy Jack Creek, a small branch of Duffer Creek. It started operations on the 15th November, 1901, but the results were poor, and work was temporarily stopped. During 1903–4 the dredge was again in commission, but the returns were unprofitable, and in 1906 the machinery was dismantled. The Golden United and Sullivan's Lead, the other dredges built on Duffer Creek, were even more unfortunate. Both started late in 1903, and were in liquidation before the end of 1904. Both were dismantled, the machinery of the Golden United going to British Columbia and that of the Sullivan's Lead to New South Wales.

Of the dredges on the western side of the Grey, the Shellback was finished late in 1901, and worked for two years with but indifferent returns. In 1903 it was sold to Allison and party, who continued to work it for several years. The dredge was finally dismantled in 1907. The Moonlight dredge started work late in 1903, and sank before the end of the year. The ground was rough but payable. In 1905 a tribute was let to Flaherty brothers, who afterwards acquired the dredge. It changed hands on several occasions, but was in nearly constant commission till the middle of 1913, when the owners (the Eureka Syndicate) had the misfortune to have their machine destroyed by fire. The Garibaldi dredge started in 1902, but returns were unpayable; next year the company was wound up and the dredge dismantled. The claim was situated on Moonlight Creek, between the crossing of the road from Blackball and the Roaring Meg junction.

Conclusion.

Of the dredges mentioned above, all save a few of the more recent were fitted with revolving screens and ladder elevators. The following sluice-box dredges have been built: Hessey, Cameron, and Tacon's, and the Frying-pan dredges on Boatman Creek, and Antonio Creek, and the Worksop dredges on Antonio's Flat. The chief advantage of the sluice-box style of dredge over the other is the avoidance of the heavy wear-and-tear incidental to the use of trommel and elevator, while in addition the first cost is decidedly less. On the other hand, the elevator enables a dredge to work much deeper ground, since the greater bulk of the tailings formed from the tight-packed wash may be piled high behind the dredge, while the sluice-box can build its tailings but a few feet higher than the original surface. Again, in dealing with large stones, especially if they be flat-sided, the elevator has the advantage, in that an extra man is required to keep the sluice-box clear. In regard to the state of the land left behind the dredge, the advantage is all with the sluice-box type. The elevator dredge deposits the fine material of the wash at the bottom of its paddock, and piles the coarse in rough unsightly heaps on the top of the fine, while the sluice-box dredge spreads fine and coarse together, leaving a fairly even surface behind it. As a gold-saver the trommel type of dredge is theoretically superior, in that the material is graded according to size before the concentration of the gold is attempted. This permits of the tables having a flatter grade than is possible in the sluice-box dredge, where, in addition, a volume of water strong enough to transport the larger stones must also be provided. In dealing with a fine-gold proposition the use of the trommel is certainly advisable, but in ordinary stream-alluvium of moderate depth the sluice-box type of dredge appears to have the advantage.

Dredging on the West Coast has been practised on an extensive scale for over fifteen years. The experimental stage was supposed to have passed before the boom of 1900 began, but as a matter of fact it is only within the last half-dozen years that sufficient data have accumulated to indicate the essential factors which must be known before the success or failure of a venture can be gauged. The main factors are the design and handling of the dredge and the nature and auriferous content of the wash. The first two are entirely within human control, and no dredging enterprise should be commenced until the latter have been investigated. In the time of the boom the designs of dredges were frequently unsuited to the conditions obtaining on the claims, or even structurally faulty. In those days, moreover, experienced dredge-men were rare, and often the dredge had shut down before the dredgemaster and his staff had acquired the technical knowledge requisite for the efficient working of the dredge. The writer believes that as many of the early dredges failed by reason of these disabilities as through lack of gold in the wash. Nowadays the materials of a dredge are usually assembled from old machines, and in so far as these materials are forced on the designer his construction may be weakened.

The amount and distribution of the detrital gold in the wash can be ascertained only by trial. The gold may be distributed fairly evenly throughout a considerable thickness of gravel, or may be concentrated in irregular bands on one or several bottoms ; and generally both conditions of distribution prevail to a certain extent. Preliminary to dredging a number of bores are usually put down in various parts of the claim, or, more rarely, shafts are sunk to the bottom of the wash. In both cases the gold contained in the material removed is carefully determined, and from the data so obtained an idea as to the auriferous content of the wash is formed. In drilling, speed is subservient to accuracy, and too much stress cannot be laid upon the care necessary in the operation to secure a sample representing as nearly as possible the value of the place drilled. The reliability of the estimate formed increases with the number of bores, but it is obvious that unless a complete system is adopted the data obtained may be very misleading. The plan of boring can only be determined after a study of the ground, and as drilling proceeds. No rule as to the number of bores required can be given, and it is here that the personal equation counts for so much. Dredging-areas, on the West Coast at least, are usually near old alluvial workings ; are sometimes, in fact, areas of low ground too wet to be worked by the early diggers. The amount of gold won from the adjacent terraces, and the history of the various leads in the locality—whether they were traced into low ground or were entirely worked out—are matters which should be taken into account by the dredge investor. However, boring as a preliminary to dredging should never be omitted, as, in addition to giving positive information as to the gold-content of the wash, it also furnishes valuable data in regard to its nature and depth, the size and frequency of the boulders it contains, and the hardness and contour of the bed-rock. Shaft-sinking is another method of determining the value of a dredging-area, and is superior to drilling in that it provides a much better opportunity of examining the character of the wash and the position of the water-level. It also enables a much larger sample of the wash to be taken out, thus decreasing the chance of error in estimating the gold-content. In this respect shafts are especially useful in loose wash, which in bores tends to give decidedly better results than the amount of gold in the wash warrants. This method, however, is more expensive than drilling, and is limited to favourable conditions, while tests by bores can be made in any class of ground. A knowledge of the nature of the wash is of the utmost importance, and has a material effect on the design of the dredge. Tight rough wash requires for successful treatment a large and powerful machine, while when boulders occur in any number fewer buckets must be placed on the ladder. These conditions add to the capital cost of a dredge and to its working-expenses by reducing its capacity and increasing the wear-and-tear. A hard and creviced rock bottom or a large proportion of clay in the wash reduces the proportion of gold saved, which under ordinary conditions does not exceed 80 per cent. of the amount in the gravel. Buried timber, however, is a far more serious difficulty on the West Coast, and when present in large amount makes successful work impossible. After the value and extent of the dredging-area have been determined, the cost of building and operating the dredge ought to be carefully considered, while the probable transport charges for material, fuel, and supplies must not be forgotten.

It will thus be seen that the investigation of a dredging proposition is not so simple a matter as the investor has too often been deluded into believing. Nevertheless the close agreement between the value of the ground as determined by skilful prospecting and the actual returns won by dredging under good conditions, together with the accuracy of the estimates of the gold to be recovered under conditions not ideal, makes dredging differ from most other gold-mining operations, inasmuch as if properly conducted it becomes more of an investment and less of a speculation.

COAL-DEPOSITS.

As already stated, the coal-seams of the Reefton Subdivision occur in three sets of beds, Tertiary in age—the Mawheranui, Oamaru, and Pareora series respectively. The seams of the oldest beds range in quality from anthracite to bituminous, those of the middle series from bituminous to brown, and those of the youngest through various grades of brown coal. The coals of the middle group are by far the most extensively developed, and up to the present they are the only ones that have been worked, although prospecting operations have been undertaken in connection with the seams of both the other horizons.

Origin of Coal-seams.

Most people are inclined to think the origin of coal-seams a purely academic question of no interest to the practical man. A little consideration, however, will satisfy any intelligent person that the elucidation of this problem is a matter of exceedingly great commercial importance. Without a knowledge of how the coal came to be formed the intelligent anticipation of the behaviour of the seams in depth, and of the occurrence and distribution of other seams that do not outcrop, must depend entirely on analogy and become decidedly less reliable.

All authorities are agreed that coal has been formed from accumulations of vegetable matter that has undergone partial decomposition by fermentative processes before being buried, but a sharp divergence of opinion prevails as to whether coal-seams result from vegetation that grew on the spot or from débris drifted from a distance. "Both the 'drift' and the 'growth-in-place' theories have been strongly urged in the past. . . In fact, the chief controversy with regard to coal during the last hundred years has always centred round these very questions. To-day authorities are perhaps as much divided as ever they were. . . . The data are so complicated, and the evidence, if considered only in part, is so liable to mislead, that many writers, beyond a statement of the chief arguments on either side, have not attempted to express any personal opinion on these matters."* Morgan† for the Greymouth, and Morgan and Bartrum‡ for the Westport,

* E. A. N. Arber: "The Natural History of Coal," 1911, pp. 82–83. † N.Z. G.S. Bull. No. 13, 1911, p. 125. ‡ N.Z. G.S. Bull. No. 17, 1915, p. 141.

district have advocated the "drift" theory for the coals occurring in these localities. The present writer, on the other hand, considers the "growth-in-place" theory more consistent with the facts observed in the Reefton Subdivision, and will present the facts supporting it.

The coal-seams themselves must be regarded as layers forming a part, though a very small part, of the whole rock-sequence, and any hypothesis of origin must take this into account. The deformative movements that preceded the laying-down of the coal-measures (undoubtedly of littoral deposition) belonging to the Mawheranui and Oamaru series were of a nature to cause the land to supply the rivers and waves with vast quantities of spoil.* At the same time the land surface drowned by the sea invasion was of a senile topography, and the recesses and embayments formed were wide and shallow; in fact, the conditions were peculiarly favourable to the formation of tidal flats and lagoons. The youngest group of coal-measures are of deltaic deposition, an origin implying the existence of extensive shallow lakes and lagoons during that period. The coal-horizon in each case is situated quite close to the basal rock of the locality, and where several seams occur they are separated by no great thickness of sediment. The seams themselves are usually contained between current-bedded sandstones and grits, from which they are usually separated by thin layers of carbonaceous shale or shaly sandstone. Occasionally fireclay is present, and seams of this occur indifferently on the roof or floor. The enclosing strata may carry many discontinuous layers of carbonaceous matter, and the roof of the seam often shows numerous minor irregularities evidently not due to movements of the coal-measure rocks. The coal-seams are decidedly lenticular, and toward the edges of the deposits the coal gradually decreases in thickness, its place being taken by carbonaceous shale or mudstone. The gradation is usually effected by the appearance of a number of dirt-layers that steadily thicken and finally entirely displace the coal, which generally in addition contains an increasing amount of ash. At other times the sandstone of the floor and roof approach until only a thin layer of carbonaceous material remains. Dirt-bands consisting of a few inches of carbonaceous shale are by no means rare, and these are also lenticular.

The existence of shallow lakes and lagoons formed by wave-action in indentations protected from the full force of the sea, or in estuaries where the currents were not strong enough to disperse the abundant river-spoil, is postulated for each coal-forming period. These sheets of water would in time be occupied by swamps, the vegetation of which would tend to creep landward up the gently sloping flats until the surface of the swamp was above the drainage-level. On rare occasions, by the combination of unusual conditions, the sea would burst the barrier it had raised, or a river would break into the morass, when a widespread layer of sediment forming a dirt-band would be deposited, of a thickness depending upon the length of time elapsing before restoration of normal conditions. At the edges of the morass a constant oscillation of conditions would occur, and the detrital matter deposited would be alternately vegetable or inorganic, but where the swamp-margin was steeper this feature would not be prominent. A slight depression of the land might cause the sea to transgress over the low-lying portion of the swamp and cover it with sand, while the higher portion would remain clear, and when the waves had built another barrier the vegetation would spread from the unburied part of the morass and occupy the newly formed lagoon. Thus could arise the splitting of seams, although this feature may have other origins. This method is indicated if no great thickness of rock separates the seams, and if the junction is in the direction of the old land and is effected by the gentle rising of the lower seam towards the upper.

The complete burial of the coal-forming swamp would follow a land-depression of slightly greater amount. The sea would transgress and kill the fresh-water vegetation.

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* See p. 83.

Its seaward margin would at first entangle much of the coarser material, and thus the earliest layers of inorganic débris would consist for the most part of fine mud only, which, intermingled with the plant-remains of the surface of the old morass, now forms the carbonaceous shale frequently found on the roof of coal-seams. No doubt at times the waves would strip off the upper layers of the swamp and expose the half-decomposed vegetable pulp beneath; but it must be borne in mind that the swamp-lagoon could have been formed only in a sheltered recess of the coast, where the waves would tend to prograde the shore, so that although part of the embryo coal-seam might be denuded the greater portion would soon be protected by a cover of beach-deposit. If the land-depression was not great the coast-line would not be essentially altered, and in course of time conditions favourable to the accumulation of vegetable matter would recur. Whether the new lagoon was inland or seaward of the old would depend upon several factors—the amount of depression, the amount of waste, the contour of the new shore, &c. As depression continued, in spite of pauses permitting progradation of sheltered portions of the coast, the first-formed beach-deposits would be covered by purely marine beds, while the marginal swamps would move inland and give rise to other seams belonging to younger overlapping layers, and in each case near the basement rock of the locality. It should be noted, however, that as the land sank, its elevation and area would constantly decrease, with a corresponding diminution of the supply of débris for beach-building. This accords well with the vertical distribution of the seams in the three Tertiary series, since they are far more frequent in the lower than in the middle, and are entirely absent in the upper layers of each group, even where these rest upon the gently sloping surface of the ancient land.

One of the axioms of geology is that the past should be interpreted in conformity with the natural forces in operation at the present time. In the writer's opinion the theory just outlined does this, the essentials being—(1) an intermittently sinking land, which also implies the existence of sheltered embayments; (2) a plentiful supply of waste; (3) a swamp deposit. The first two conditions were undoubtedly fulfilled during the Tertiary, while examples of the third, known to the writer, are furnished by many of the morasses of the Piako Plain. In depth these consist of half-decomposed vegetable pulp, and contain considerable quantities of resinous particles and lumps, as well as the trunks of trees of which the groves were overwhelmed long since, when the land was depressed. These, if buried by sand and mud, could well form coal-seams. Strictly analogous with them are the lignites of Tauranga Harbour, which contain tree-stumps and fallen boles set in a structureless mass.* These seams were formed during the post-Tertiary depression, and that they accumulated by growth in the place they now occupy cannot be doubted.

It must, however, be admitted that the occurrence of well-rolled pebbles of quartz or rock such as are occasionally found in the coal-seams of the Greymouth,† Pakawau, Shag Point, and Green Island‡ districts are not satisfactorily accounted for by the theory of coal-genesis just outlined. The explanation offered by the "drift" theory—that they owe their position to entanglement among floating vegetation—though not free from objection, is more plausible than any hypothesis that the writer could devise with the "growth-in-place" theory as a basis.

Another objection urged against the swamp "growth-in-place" theory is that the peat of existing swamps contains, when dried, rarely less than 5 per cent. of ash,§ and that coal formed from this material would contain an ash percentage far above

* N.Z. G.S. Bull. No. 16, 1913, p. 76.
† N.Z. G.S. Bull. No. 13, 1911, pp. 123 and 125.
‡ Hutton, F. W., and Ulrich, G. H. F.: "Geology of Otago," 1875, p. 103.
§ Clarke, F. W.: "The Data of Geochemistry," 1911, U.S. G.S. Bull. No. 491, p. 709. Kummell, H. B.: "The Peat Deposits of New Jersey." *Economic Geology*, vol. ii, 1907, p. 26.

that of even the dirtiest of the West Coast seams. An inquiry, however, into the nature of the ash of wood, peat, and coal causes this objection to lose much of its weight. The following table of typical examples of ash of various fuels shows that a very large proportion of the ash of peat must be readily soluble in swamp waters :—

——	Oak Wood* (contains 2 per Cent. of Ash).	Irish Peat.†	Lignite, Hungary.‡	Steam Coal,§ Ebbw Vale, Wales.	Natural Coke, Chasm Creek.‖
K_2O	8·43	1·323	2·38	..	1·35
Na_2O	5·65	1·902	0·38	..	
CaO	75·45	36·496	15·62	3·94	3·16
MgO	4·49	7·634	3·64	2·20	0·54
Al_2O_3	0·57	5·411	23·07	35·01	11·50
Fe_2O_3		15·608	5·05		53·84
MnO	..	..	1·13	..	0·80
P_2O_5	3·46	2·571	..	0·88	..
SO_3	1·16	14·092	12·35	4·89	..
Cl	0·01	1·482	1·55	..	..
CO_2	..	7·761	..	..	..
SiO_2	0·78	3·595	36·01	53·00	26·74
TiO_2	..	..	..	..	0·92
Insoluble in acid	..	2·168	..	..	..
Undetermined (? carbon) ..	..	..	..	..	1·15
Totals	100·00	100·043	101·18	99·92	100·00

* Percy, J. : "Metallurgy, Fuel, &c.," 1875, p. 196. † *Ibid.*, p. 209. ‡ *Ibid.*, p. 351. § *Ibid.*, p. 352. ‖ N.Z. G.S. Bull. No. 17, p. 171. For numerous analyses of the ashes of New South Wales cokes see "The Coke Industry of New South Wales," 1916, pp. 83 and 84.

Distributon of the Coal-deposits.

If the earth-structure of the subdivision has been correctly interpreted, and if the principles controlling the formation of coal-seams are essentially as set forth in the section above, it becomes possible to indicate, with an exactness depending on the number of data available, the position and extent of the coal-bearing areas. Thus it is known that the movement that preceded the Mawheranui period was accompanied by radial faulting and the differential elevation of adjacent earth-blocks. Since similar movements, some of which were undoubtedly along the same fractures, determined the present land-form, it is reasonable to assume that the land-features now existing were already taking shape. Apparently the sea during Mawheranui times covered the southern end of the Paparoa block to at least as far as the Freeth River, and it may be supposed that an arm extended still farther northward along the graben and across to its eastern border. Doubtless also the depression extended far into the land, and was drained by a considerable stream that brought down an abundant supply of waste, and the conditions must have been peculiarly favourable for the formation of coal-seams. It seems probable, then, that a fringe of coal-lenses extends along the margin of the ancient gulf, and that workable seams, though at a very great depth, exist as far north as Hukarere. On the western side of the Paparoa Range the problem of the distribution of the coal-measures of this age is not so simple. There is some evidence in the breccia and breccia-conglomerate beds of Bullock Creek and Brighton that a rift-valley, of which the western wall has long since foundered and of which the floor only remains, was formed, and in the anthracites of the Fox River that coal accumulated in it during that period. On the other hand, it is known that elevation and erosion took place before the deposition of the overlying Oamaru beds, and there are no data to show how far this erosion went. There is, however, a reasonable possibility that a great part of the coastal region has a layer of coal-measures of Mawheranui age interposed between the basement rock and the overlying Late Tertiary strata. This and the depth of the coal-bearing horizon can only be determined by boring. It should be noted that from the Punakaiki northward the bore would have to penetrate, before reaching the older Tertiary rocks, only a shallow thickness of the lower beds of Oamaru Series, which themselves also contain a coal-horizon.

The distribution of the Oamaru rocks is sufficiently indicated in the accompanying geological maps of the subdivision. It is probable that they underlie the whole of the Inangahua trough to a depth steadily increasing from the north southward. That conditions favourable for the formation of coal-seams prevailed over wide marginal belts during the early Oamaru period is certain ; but that these belts, due to successive depressions at irregular intervals, form a continuous sheet beneath the younger purely marine beds of the same series is very doubtful, and where other information is not at hand the distribution and commercial value of the hidden coal-lenses can only be determined by systematic boring.

No workings have hitherto been undertaken in the coal-seams of Pareora age, but from the study of the outcrops they appear to be decidedly more irregular both in thickness and composition than the seams of earlier age. On this account the writer considers that exploration by boring is even more essential in connection with these seams than for the coals of the Oamaru and Mawheranui measures.

Composition of the Coal.

The transformation of vegetable matter into coal of various grades is recognized to have been effected by a slow distillation. It is obvious that this process, as applied in respect to the layers of vegetable material contained in rocks of various character, is very different from the distillation of the same material in the laboratory, and it is manifestly impossible there to reproduce conditions identical with those obtaining in nature. Nevertheless the main factors on which the composition of the final product of a distillation depend are as potent in the one process as in the other. These are (1) the nature of the original substance, (2) the time occupied in the distillation, (3) the intensity of the heat, (4) the physical pressure to which the material is subjected, and (5) the facilities of escape afforded the gaseous products of the process.

Nature of the Original Substance.

Some authorities consider that although the change from peat to brown coal is established, no process or combination of conditions and processes could convert a brown coal into a bituminous coal or an anthracite ; in fact, they maintain that the "mother substances" of these coals were originally essentially different.* This hypothesis seems to be also based, in part at least, on the erroneous supposition that bituminous and anthracitic coals are confined to rocks of a Palæozoic age.† In the Reefton Subdivision, however, the coals of the Oamaru Series range from brown to bituminous coal, while if the whole of the Tertiary coals be considered the range is from brown coal to anthracite. With such wide differences in the composition of coals not differing greatly in age, and laid down under similar conditions, it seems

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* See the papers by Donath and his associates, quoted by F. W. Clarke in "The Data of Geochemistry." U.S. G.S. Bull. No. 491, 1911, p. 715.

† Newell Arber, E. A. : "The Natural History of Coal," 1911, p. 69.

indeed extremely hazardous and entirely unnecessary to postulate material differences in the original "mother substance," especially as such an assumption is unsupported by positive evidence. On the other hand, although the chemical composition is similar, there is a decided difference in the physical structure of the coals of the Pareora Series when these are compared with the lignitic material* occurring in the same set of beds. In the case of the lignitic material the woody structure and bark of the tree-stems, which have been much flattened out, is plainly discernible, while the coal is apparently homogeneous. It is suggested that the coal has been formed from partially decomposed vegetable débris accumulated under water, while the lignitic bands represent forest growth overwhelmed by sedimentation. The "doughboys" of Seddonville may represent portions of tree-trunks contained in swamps, but still sound, or at least not completely decomposed, when the fermentative action of the bacteria was checked by burial beneath inorganic débris. Later the distillation processes destroyed all trace of woody tissue, and left material differing considerably in physical, but not in chemical, properties from the surrounding coal.

Age of the Coal-seams in Relation to their Composition.

The time during which the vegetable matter has been subjected to the slow distillation has had a decided influence on—in fact, by many is considered the main factor in determining—the nature and composition of the resultant product. In New Zealand, however, it was long ago† recognized that the mere lapse of time would not reasonably explain the variations in the grades of coal. On the West Coast, where the seams lie flat or gently inclined, the effect of age on the composition of the coal is shown by the following table representing the range of the average coals of each series :—

	Mawheranui Series.	Oamaru Series.	Pareora Series.
Fixed carbon	66–45	50–32	40–42
Hydrocarbons	33–45	42–50	45–38
Water	1–10	8–18	15–20

As the coals of each group do not differ greatly in age among themselves it is evident that the composition does not depend entirely on time.

Heat of Distillation.

The effect of this factor is best seen where coal-seams have been altered by the intrusion of igneous rocks. An example of such metamorphism is unknown on the West Coast, but may be studied in connection with the coal-seams of the Malvern Hills, Canterbury.‡

Physical Pressure.

This is produced by crustal stresses, and in the Reefton Subdivision there are numerous examples of coal-alteration brought about chiefly by the pressure accompanying fault-movements. Thus the fault-involved coal-seams of the Fox River belonging to the

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* The following analysis of lignitic material from a band in Ford Creek (a small branch of Blackwater Creek, Mawheraiti Survey District) may be compared with those on pp. 217, 218 :—

		Reduced to an Ash-free Basis.
Fixed carbons	22·84	37·0
Hydrocarbons	28·20	45·7
Water	10·71	17·3
Ash	38·25	..
	100·00	100·00
Sulphur	0·74	

† Hutton, F. W. : "Report on the Geology and Goldfields of Otago," 1875, p. 98.

‡ Evans, W. P. : "Contact Metamorphism at the New Brockley Coal-mine." Trans., vol. xxxi, 1899, p. 557 *et seq.*

Mawheranui Series have the composition of high-grade anthracite, while the flat-lying seams of the same age contain bituminous coal only. Another example, and one exhibited by the coals of the Oamaru Series, will suffice. At Murray Creek the coal, where not crushed by faults, contains 50 per cent. of fixed carbon and 5 per cent. of water, figures altered to 52 per cent. and 2·7 per cent. respectively only a few chains away, where it is strongly crushed but not pulped. In this locality pitch has been found, presumably produced by the heating of the coal by earth-movements.

Facilities for the Escape of the Gaseous Products.

As far as the writer is aware, the effect that a ready means of escape for the gaseous products of distillation has on the composition of coal was first brought into prominence by M. R. Campbell.* He considers that "the whole process of transformation of vegetable matter into coal is controlled by the porosity of the overlying rocks."† This in turn depends not only upon the original physical character of the rocks, but also upon the joint- and cleavage-planes developed by earth-movements. It is probable that this factor has been more largely concerned in the alteration of coal in the neighbourhood of faults than the pressure exerted by the stress producing the fault. To account for all the differences in composition of the coals in the Reefton Subdivision is very difficult, and no doubt the various grades were produced by the operation of a combination of several of the factors enumerated, and of others unknown. The hypothesis of rock-porosity, however, so aptly explains so many of the observed facts that the writer considers it the dominant factor in determining the nature of the coal. It is not proposed in this place to detail all the facts leading to this conclusion, but it may be stated that in a general way the coals of the Oamaru Series alter with the nature of the rocks containing them. Thus on the Reefton plateau, where the measures consist almost entirely of conglomerate, grit, and coarse sandstone, the coal is almost bituminous in character. At Brighton, on the other hand, where the measures consist of no great thickness of sandstone overlain by a great thickness of impervious argillaceous sandstone and limestone, the seams are of brown coal. Where the measures are of a permeability intermediate between these extremes the coal is of intermediate grade.

Detailed Description of the Coal-seams.

For convenience of description the coal-seams of the subdivision may be divided into a number of groups. The separation adopted depends primarily on time, and secondly on distribution.

Mawheranui Series—Eocene(?) .. ..
- (1) Greymouth group.
- (2) Porarari group.
- (3) Fox River group.

Oamaru Series—Lower Miocene .. ..
- (1) Buller Gorge group.
- (2) Three-channel Flat group.
- (3) Fletcher Creek group.
- (4) Reefton group.
- (5) Plateau group.
- (6) Waiwhero group.
- (7) Garden Gully group.
- (8) Brighton group.

Pareora Series—Upper Miocene .. ..
- (1) Giles Creek group
- (2) Camp Creek group.

* "Hypothesis to account for the Transformation of Vegetable Matter into the Different Grades of Coal.' *Economic Geology*, vol. i, 1906, p. 26 *et seq.*

† *Op. cit.*, p. 30.

Greymouth Group.

The area of coal-bearing rocks to which this name has been given forms the southern end of the Paparoa Range, and contains all the valuable seams worked in the Greymouth district. A small portion of this area enters the southern boundary of the Reefton Subdivision, and this, together with the very important major section, has already been adequately described in Bulletin No. 13, to which publication the reader is referred for details.

*Porarari Group.**

A small outlier of coal-bearing strata, consisting of conglomerate, grit, and sandstone, isolated by crustal movements and denudation, occurs on the divide between the Porarari and Punakaiki rivers on the one side and the Big (Freeth) River on the other. Several outcrops are reported to occur in the Porarari fall, and one seam, of which the position is roughly indicated on the map, crops out near the crest of the ridge. The writer had no opportunity of examining this remote locality. The coal-fragments noted in the bed of the Pike Stream and the main south branch of the Porarari River indicate that the seams consist of bituminous coal. Several square miles of apparently horizontally disposed and probably little disturbed coal-measure strata may here exist, and as some of the seams are reported to be of good workable thickness the area, in spite of the difficulty of access, may yet prove worthy of commercial exploitation.

Fox River Group.

A small patch of steeply dipping and fault-traversed coal-bearing rocks of Eocene age lying between the two headwater branches of the Fox River forms the area here considered. About a mile up the north branch from the forks there is an outcrop of coal-measures consisting of grit (here altered to quartzite), conglomerate, and shale containing small coal-bands from 2 in. to 6 in. thick. The strike is nearly north-east, and the dip south-east at 60°. Thirty chains up-stream a similar set of beds striking north-north-east, and dipping west at about 80°, contains several seams from 1 in. to 9 in. thick. On the hillsides in this locality it is stated that a prospecting party discovered 26 ft. of crushed coal and two outcrops of hard anthracitic coal 7 ft. and 11 ft. thick respectively. In the south branch of the Fox (Henniker Stream) an outcrop of exceedingly crushed carbonaceous shale only was observed. The following analyses of the coal from this locality may be quoted. They show the anthracitic nature of the material.

	(1.)	(2.)	(3.)	(4.)	(5.)	(6.)	(7.)
Fixed carbon	71·80	79·65	79·81	90·90	82·42	82·70	82·14
Volatile hydrocarbons ..	5·79	6·56	4·93	5·10	11·07	9·43	12·08
Water	4·18	3·61	0·86	0·80	0·23	1·05	0·71
Ash	18·23	10·18	14·40	3·20	6·28	6·82	5·07
Totals	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Sulphur	..	..	..	..	0·35	0·57	0·67
Specific gravity ..	..	..	..	..	..	..	1·32

(1) and (2). Probably from upper outcrops on Fox River. Lab. Rep. No. 29, 1895, p. 10.
(3.) Probably from lower outcrop on Fox River. *Ibid.*
(4.) Fox River. Lab. Rep. No. 35, 1901, p. 7.
(5.) Fox River. Lab. Rep. No. 40, 1907, p. 10.
(6.) Fox River. Lab. Rep. No. 44, 1911, p. 9.
(7.) Fox River. From 3 in. seam in upper set of outcrops, collected by the writer.

* See also N.Z. G.S. Fifth Ann. Rep., C.–9, 1911, p. 13.

The coal-measures of this locality have been prospected, but the strata are so shattered that there is no likelihood of commercially valuable seams ever being found in them. The occurrence is of value only as indicating the possibility that the coal-horizon to which the seams belong lies beneath the younger beds that cover the lower ground between the mountains and the sea. This possibility is strengthened—indeed, becomes a probability—from the fact that the breccia-conglomerates that lie beneath the Mawheranui coal-measures outcrop near the mouth of the Fox River. These, before disappearing beneath the younger strata, are overlain by grits and carbonaceous shale that apparently belong to the coal-bearing horizon. The belt of country lying immediately to the westward of the Paparoa Range is a potential coalfield, the value of which can only be proved by systematic boring. In structure it resembles the probable coalfield beneath the Westport flats, of which it may be regarded as a southern extension. It is likely on structural grounds that the ridges of ancient rock represented on the coast by the gneiss of Tuhinu Hill and the granite of the Gentle Annie Rocks cut off this coal-bearing area on the north and south respectively, and its meridional extension would on this account be little more than its east-and-west width at the Fox River—that is, five miles. The later Tertiary covering-strata are undisturbed and have a gentle easterly dip, and if the Mawheranui beds maintain the dip at their outcrop near the mouth of the Fox River the coal-horizon would lie many thousands of feet below the surface near the mountains. There is, however, a reasonable hope that the horizon is at a much shallower depth, but this can be ascertained only by boring. The chief indication of the possible existence of workable seams is to be found in the reported thicknesses mentioned on a previous page. On the theoretical grounds already discussed it is probable that the coal will not be anthracitic, but will range in quality from semi-bituminous to bituminous.

Buller Gorge Group.

The first mention of the working of the seams of this group is by the Inspector of Mines, who reports that Mr. C. Croawell in 1884 took out 20 tons from a pit, of which the exact locality is unknown to the writer. The Coal Creek Mine is situated not in Coal Creek, but on the Buller Road about two miles below Mr. George Walker's station, "Rocklands." It was worked by Mr. Berlin and others prior to 1887, but it was not until 1897 that the requirements of the Excelsior dredge caused the mine to be systematically opened. In 1900 it was taken up by Mr. Walker for the purpose of supplying the Rocklands dredge. Work was continued regularly until 1907, when the demand for steam coal slackened owing to the shutting-down of some of the dredges in the vicinity. The property now belongs to Mr. John Burley, by whom it is intermittently worked. The Whitecliffs Mine, situated on Coal Creek a short distance from the Buller Road, was opened in 1891 to furnish the Whitecliffs dredge with fuel. The vicissitudes and voyagings of this machine have already been mentioned, and its coal-supply was drawn either from this mine or from Three-channel Flat, whichever was the more convenient. The mine was closed in 1897 but reopened in 1901, and was regularly worked while the dredges were in operation. It is now owned by Mr. Job Lines, and is worked as occasion requires by Mr. James Burley. Altogether about 14,000 tons are recorded as having been mined from this locality, of which the Coal Creek and Whitecliffs mines have each supplied a nearly equal quota.

What may be termed the Buller Gorge coalfield consists of a strip of country that stretches from Slug Creek (a tributary of Pensini Creek) on the north to Nada Creek (a tributary of the Buller Blackwater) on the south. The extreme coal-outcrops are thirteen miles apart, and of this distance eight miles lie within the Reefton

Subdivision, the area crossing the northern portion of the Inangahua Survey District diagonally. The width of the possibly coal-bearing area is, on the northern boundary of the subdivision, at least a mile and a half; while southward, in which quarter connection is probably made with the main Inangahua graben, this width may increase, although as the coal-outcrops in this direction are confined to the western edge nothing definite can be said. The strata in which the seams are contained are of Oamaru age.

The accompanying table shows the composition of the coals from this area. Analyses of samples from Pensini and Nada creeks, indicating the nature of the seams from the northern and southern portions of the field respectively, are also included.

——	(1.)	(2.)	(3.)	(4.)	(5.)	(6.)	(7.)	(8.)	(9.)	(10.)
Fixed carbon ..	44·16	49·36	43·84	44·46	45·92	48·14	40·62	41·78	42·29	37·60
Volatile hydrocarbons ..	44·26	42·38	41·00	43·11	30·63	32·20	43·26	41·95	41·59	38·67
Water	10·22	7·81	12·48	10·56	15·86	17·40	13·52	12·20	12·67	18·65
Ash	1·36	0·45	2·68	1·87	7·59	2·26	2·60	4·07	3·45	5·08
Totals	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Sulphur	4·18	3·99	3·35	2·69	..	..	4·50	2·92	2·65	4·28
Specific gravity ..	..	1·28	..	..	..	..	..	..	..	..
Calories per gramme ..	6,077	7,004	5,896	6,376	..	..	6,189	5,969	5,902	..
British thermal units per pound	10,398	..	10,612	11,476	..	..	11,140	10,744	10,624	..
Evaporative power per pound	11·34	..	11·00	11·90	..	..	11·55	11·14	11·01	..
Practical evaporative power (assuming 60° efficiency)	..	..	6·60	7·14	5·9	..	6·93	6·68	6·61	..

(1.) Pensini Creek, 8 ft. seam. N.Z. G.S. Bull. No. 17, 1915, p. 178.
(2.) Blue Duck Creek, lower outcrop. *Ibid.*, p. 173. Gives a firm swollen coke.
(3.) McIntosh Creek, at crossing of Three-channel Flat - Mackley Track. Does not form a coke.
(4.) Muddy Creek water-race, 4 ft. Forms a fairly firm coke.
(5.) Coal Creek, south side of Buller River. Lab. Rep. No. 11, 1876, p. 13.
(6.) Coal Creek. Analyst, Sidney Fry (personal communication).
(7.) Coal Creek Mine, 16 ft. seam. Lab. Rep. No. 47, 1914, p. 16. Gives a pulverulent coke.
(8.) Felix Creek, lower outcrop.
(9.) Felix Creek, 7 ft. seam. Does not form a coke.
(10.) Nada Creek, large seam. N.Z. G.S. Bull. No. 17, 1915, p. 173.

The coal-outcrops found in Slug and upper Pensini creeks, where thicknesses of from 4 ft. to 8 ft. occur, and in Blue Duck Creek, where the seam or seams appear to be somewhat thinner, have been described in a former publication.* In close connection with this northern group of outcrops are the coals occurring in the upper valley of McIntosh Creek. The outcrops in this locality are very obscure; and beyond stating that the containing beds consist chiefly of flat-lying grit, that the coal lies close to the basement rocks, and that the two outcrops marked probably belong to the same seam, which is at least 5 ft. thick at the lower outcrop, nothing can be said. Passing southward along the western side of this coal-bearing area from the lower outcrop in Blue Duck Creek, where 4 ft. of coal in two bands is

* N.Z. G.S. Bull. No. 17, 1915, pp. 178–79.

exposed, the coal-bearing horizon is next represented by a layer of carbonaceous shale overlying quartz-porphyry near the point where the Orikaka breaks from its gorge. Coal at least 4 ft. in thickness outcrops on the old water-race of the Wellington Sluicing Company near Muddy Creek, and what is probably the same seam is reported to show on the hillsides between this point and the Buller River. South of this stream 15 ft. of clean fairly hard coal is worked at the Coal Creek Mine. The seam is here separated from bleached and decomposed quartz-porphyry by grit, perhaps 5 ft. in thickness, and is overlain by 9 in. of grit that passes upwards into claystone. Probably the same seam, possibly displaced by a small fault, is worked at the Whitecliffs Mine, where the decidedly irregular roof of the seam is overlain by grit and fine conglomerate. The floor was not seen, although 16 ft. of coal is exposed. The strike at the Coal Creek Mine is 24° west of north, and the dip 25° to the eastward; at Whitecliffs the figures are 5° west of north and 12° to the east respectively. Near the head of Felix Creek (a tributary of Berlin Creek) what is probably the same seam outcrops for several chains. The coal is clean and hard, and is at least 7 ft. thick, but the floor is nowhere visible. The strike of the strata is north and south, and the dip is westward at 20°.

Three-channel Flat Group.

The only mine regularly worked in this locality is generally known as the Flaxbush Creek Mine, although it is situated on neither of the Flaxbush creeks. It is also sometimes called the Cocksparrow Mine, from the fact that it was opened in order to supply the dredge of that name, or De Filippi's mine, after the lessee. Since the coal obtained was useful only for steaming purposes, the output depended entirely on the fuel required by the dredges in the locality. Thus it was opened in 1895, but was shut down again in a few months and not reopened until 1899, from which date it was regularly worked for ten years, 8,000 tons in all being extracted. The seam, which was much crushed, and 2 ft. in thickness, dipped at a steep angle to the westward, and was worked on a modification of the long-wall system, or, rather, by an overhand stoping-system similar to that employed in ordinary lode-mining.

In the valley of Thompson Creek, on the opposite side of the Buller River, a seam varying from 2 ft. to 3 ft. in thickness has been stripped and removed to the extent of about an acre. The coal was transported in a sluice-box to the mouth of the creek, and thence taken by boat to the Mokoia dredge. There is no record of the amount of coal removed from this locality.

The coal-seams of the Three-channel Flat group occur in strata of Miocene age, at the northern extremity of the Inangahua graben, where, on the eastern side, outcrops or shoad occur in all the streams from Ram Creek to the Flaxbush Mine. On the western side coal shows in Thompson Creek, on the hillside on the right bank of the Buller opposite De Filippi's house; and in addition coal-fragments were noted in the bed of upper Welshman Creek, while "coal has been reported as occurring near Pensini Creek about two miles above its junction with the Buller."* These outcrops indicate an area about six miles long, and from two and a half to three and a half miles wide, as possibly coal-bearing.

The outcrop opposite De Filippi's house is 770 ft. above sea-level; the seam is only 2 ft. in thickness, and its relationships are not well exposed. In Thompson Creek numerous outcrops of crushed coal occur. At one place 6 ft. of impure coal is apparently underlain by claystone containing numerous marine fossils, but the

* N.Z. G.S. Bull. No. 17, 1915, p. 178.

whole exposure is greatly crushed and faulted. The lowest outcrop noted showed 3 ft. of flat-lying coal, while a similar thickness was worked by stripping in a small right-hand tributary, the seam here striking north-north-east, and dipping eastward at about 30°. The roof and floor consists of green argillaceous sandstone.

The outcrops along the flank of the Brunner Range exhibit much more satisfactory thicknesses. The poorest of these was worked at the Flaxbush Mine, where three seams, 6 ft., 2 ft., and 20 in. respectively, occur. Only the 2 ft. seam was worked, the larger one being very dirty. The seams are much faulted, strike north and south, and dip 60° or more to the westward. In Little Flaxbush Creek, about half a mile to the southward, a seam striking north-west with a dip of 65° to the north-east shows 10 ft. of clean coal set in micaceous mudstone contained between coarse grit and sandstone. To the dip the seam divides, the lower split maintaining a thickness of 2½ ft. of coal, while the upper thins rapidly and, bending over, joins the lower again over a "horse" of mudstone 3½ ft. thick. In Big Flaxbush Creek two seams occur, the lower 1 ft. and the upper 8 ft. to 10 ft. thick, separated by about 12 ft. of alternate layers of sandstone and mudstone. The floor of the lower is fine sandstone, and the roof of the upper sandstone and fine grit. The strike is nearly north and south, and the dip westward at about 60°. In Ram Creek no coal was noted *in situ*, but in the neighbourhood of the main fault-zone numerous coal-fragments occurred in the stream-bed.

ANALYSES OF COALS OF THREE-CHANNEL FLAT GROUP.

—	(1.)	(2.)	(3.)	(4.)	(5.)	(6.)	(7.)	(8.)	(9.)
Fixed carbon	35·38	27·13	42·03	39·97	42·54	37·69	42·19	42·54	38·46
Volatile hydrocarbons ..	42·30	27·66	40·13	39·54	40·89	42·23	42·81	46·35	45·54
Water	16·17	11·85	14·67	17·27	15·68	11·55	14·14	9·53	8·25
Ash	6·15	33·36	3·17	3·22	0·89	8·53	0·86	1·58	7·75
Totals	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Sulphur	4·34	3·57	4·10	3·75	6·48	5·71	6·51	6·04	6·84
Specific gravity	..	1·71	..	1·31	1·31	..	..	..	..
Calories per gramme	5,191	5,245	..	..	..	5,387	5,766	6,391	6,043
British thermal units per pound	9,343	9,441	..	..	..	9,696	10,379	11,504	10,870
Evaporative power per pound ..	9·68	9·78	..	..	..	10·05	10·76	11·92	..
Practical evaporative power (60° efficiency)	5·81	5·86	..	..	..	6·03	6·46	7·15	6·7

(1.) 2 ft. seam, on west side of Buller River opposite De Filippi's house. Does not coke.

(2.) 6 ft. seam, crushed and rusty, Thompson Creek.

(3.) 3 ft. seam, about 8 chains to the west of Thompson Creek. Forms pulverulent coke.

(4.) 3 ft. seam, lowest outcrop in Thompson Creek.

(5.) 10 ft. seam, Little Flaxbush Creek.

(6.) 2½ ft. lower split of Little Flaxbush seam. Forms pulverulent coke.

(7.) 4 ft. upper split of Little Flaxbush Creek seam.

(8.) 10 ft. seam, Big Flaxbush Creek. Forms a pulverulent coke.

(9.) 1 ft. lower seam, Big Flaxbush Creek. Forms a firm coke.

Fletcher Creek Group.

In the basin of Fletcher Creek thick seams occur which up to the present time have been neither worked nor prospected. Coal outcrops in the main branch of Fletcher Creek and in Coll Creek, a southern tributary, but southward the next stream from the mountains shows the limestone that overlies the horizon resting directly on granite. Northward no trace of coal was noted in Hunt or McMurray creeks, but in Shag Creek a thick seam (20 ft.) is reported to outcrop about two miles above its junction, while a seam at least 4 ft. thick was laid bare by sluicing operations in York Creek about a mile from the Inangahua River. This coal-bearing area is probably connected with the Buller Gorge area by way of the seams of Nada Creek.

In Fletcher Creek itself there are three large outcrops. The relationships of the lowest of these, which is obviously fault-involved, are not clear. To the eastward are undoubted Pareora beds, while to the westward the rocks are of the Oamaru Series, all steeply dipping. Thus this seam, which is at least 12 ft. thick, may belong either to the Oamaru or Pareora series, at the junction of which it outcrops. The coal is hard and clean. About a mile farther up the creek a seam from 20 ft. to 25 ft. thick outcrops. The strike is north-north-east, and the dip easterly at about 20°. The immediate roof and floor were not observed, but a few feet away consist of arkositic grit containing oysters and calcareous algæ, and sandstone containing shell-fragments and calcareous concretions respectively. About half a mile farther up-stream what was evidently at one time a very thick seam is fault-involved in granite. In Coll Creek a seam 12 ft. to 16 ft. thick, with a steep easterly dip, occurs. Its strike is about north-north-east, and its relations to the neighbouring rocks were obscured by gravels.

Samples taken from some of these outcrops were analysed, with the following results :—

	(1.)	(2.)	(3.)
Fixed carbon	40·52	38·70	36·06
Volatile hydrocarbons	43·91	40·57	47·36
Water	14·04	17·31	14·70
Ash	1·53	3·42	1·88
	100·00	100·00	100·00
Sulphur	0·46	5·64	4·62

(1.) Large seam forming lowest outcrop in Fletcher Creek.
(2.) 25 ft. seam forming middle outcrop in Fletcher Creek.
(3.) 12 ft. to 16 ft. seam in Coll Creek.
None of these formed a coke.

Reefton Group.

From Italian Gully on the north to Devil Creek on the south, a distance of eight miles, coal outcrops in nearly every stream issuing from the Reefton hills. In most of the sections at least two seams of good workable thickness are exposed. The coal is semi-bituminous in quality, is a good steam coal, and is considered by many to be the best household coal found on the West Coast.

The writer is informed that a large outcrop was exposed in Soldier Creek close to the present township when that creek was "rushed" early in 1867. It is probably from this locality that the first coal was mined from the seams of this group. In 1874 the seams near Capleston are reported to have been discovered, and it appears likely that those of the Burke Creek basin were known before this, having, in fact, been worked as early as 1873. Cox* in 1875 reports that coal had been mined from the hill to the east of Reefton, and that the Reefton Coal Company, having

* Rep. Geol. Explor. during 1874–76, No. 9, 1877, p. 78.

constructed a tramway across the top of the same hill, was preparing to open out on a 21 ft. seam outcropping in the Burke Creek fall. The mines in this locality were known also by the names of Dudley and New Durham, while that opened in Devil Creek, worked by Breen, was called the Newcastle. The earliest report of the Inspector of Mines, Mr. G. J. Binns, states that the seams of Burk Creek* near Capleston were being worked by a Mr. H. Dugan in 1879, who packed the coal to the township. For many years the mines near Capleston were worked on a very small scale, but on dredging commencing in this locality in 1898 the output was increased. Two seams outcropping on the Waitahu River were first attacked in 1884 and again in 1894, but in neither case was more than a few tons extracted, and it was not until 1904 that this mine was systematically opened, the lessee on this occasion being Mr. J. Scarlett, of Reefton. This mine, like others in the district, has changed hands frequently, some of the owners being O'Donnell, Jude, and Rhodes. A seam at Madman Creek was opened up by Mr. R. Cochrane in 1893, but was abandoned in the following year. This ground was taken up a few years ago by Messrs. Morris and Learmont, and has been worked to some extent by them. The seams outcropping in Stony Batter Creek were first opened up in 1898 by Messrs. Cairnes and McLiver, and this property afterwards came into the control of Messrs. Harris and Gibson, who energetically worked it. Mr. E. Lockington developed a coal-bearing area in the Burke Creek basin in 1902, and mining has proceeded here more or less continuously ever since. In 1902 Mr. D. Blackadder took up part of the Reefton Town Belt, and after a good deal of trouble succeeded in proving a large seam behind the crushed and slipped country that in this locality forms the face of the hill. This property was acquired by Mr. James Billet in 1906, and has been worked fairly constantly up to the present. A higher seam, 4½ ft. thick, was found in 1907 by Mr. James Morris, and worked to a certain extent by him. The Devil Creek area, which in the "seventies" was energetically exploited by Mr. James Breen, and was in late years intermittently worked by various owners, was again opened up in 1910 by Mr. R. L. Kearns, who has taken out a few hundred tons yearly since that date.

The most northerly coal-outcrop belonging to this group is near the junction of Italian Gully with Raglan Creek, where coal mixed with clay and sandstone occurs in a crush-zone. Involved in the same fault thick outcrops of crushed coal appear in Howell's claim and Burk Creek. In Coal Creek (a small branch of Burk Creek) a seam 21 ft. thick and rather crushed is reported, and at its head Archer's mine is situated. There two seams of excellent coal, each from 10 ft. to 16 ft. thick, and separated by about 60 ft. of gritty sandstone, are worked The faces at the time of the writer's visit were standing at a north-west-striking fault, with downthrow to the south-west. Coghlan's mine is on the Capleston side of the same hill, the whole western face of which is disturbed to a greater or less extent by the fault along Boatman Creek, and the coal here mined is in consequence decidedly friable. On the western side of the main stream the two seams already mentioned are represented, the upper by 5 ft. to 7 ft. of clean hard coal, and the lower by a bed of carbonaceous claystone about 4 ft. thick, and containing perhaps 18 in. of coal. The seams are here about 80 ft. apart. In Flower Creek, 25 chains farther west, a coal-band 20 in. thick, believed to be the upper seam, occurs. On the right bank of the Waitahu River three seams outcrop, the highest of which shows from 12 ft. to 16 ft. of clean coal, the middle about 5 ft., and the lowest 2 ft. The intervening beds, which in both cases are about 100 ft. thick, consist chiefly of grit with minor layers of sandstone and carbonaceous shale. The two larger seams are worked, the faces when visited standing against an upthrow fault. South of the river the first signs of coal observed are on

* H.-18, 1880, p. 13.

the track to the Inglewood Mine, on which crushed carbonaceous claystone and coal occur. On Madman Creek Morris and Learmont have partly developed a 20 ft. seam of first-class coal, and the writer was informed that another outcrop occurs about 15 chains down their tram, in the low hills to the north of it. In Stony Batter Creek are two seams respectively 16 ft. and 5 ft. in thickness, while higher up the creek is the outcrop of a very large seam, somewhat faulted, but apparently belonging to a third seam. The two upper seams are separated by about 100 ft. of sandstone and shale, and the higher or 16 ft. seam only is worked. Between Stony Batter and Madman creeks several outcrops were visited, and are indicated approximately on the map, but their relationships could not be definitely traced. On the eastern side of Burke Creek two seams have received attention. That originally opened by Mr. E. Lockington is undoubtedly the large seam worked in Stony Batter Creek, although a fault of some kind separates the outcrops. The seam is reported to contain stone and pyritic bands, and to be about 12 ft. thick. About 20 chains farther up-stream a 20 ft. seam of clean coal is being worked. On the opposite side of the creek outcrops undoubtedly belonging to the same seams have been worked to some extent. The seam lowest in the sequence was worked in the "seventies" by various lessees, while the other was opened up, although little coal was extracted, by Messrs. Morris and Leishman a few years ago. Cox* reports that the former seam shows 21 ft. of coal resting on 3 ft. of fireclay followed by a further 3 ft. of coal, while the latter is 10 ft. to 12 ft. thick. The two seams outcropping within the Reefton town boundary are separated by 100 ft. of rock, and exhibit thicknesses (the upper) of 4½ ft. and (the lower) of 12 ft. to 16 ft. The coal of the latter, however, is inferior, containing ash and pyritic bands. In the lower valley of Devil Creek the seams are obviously fault-involved. Coal 8 ft. in thickness and standing at a high angle outcrops on the roadside, and is almost certainly connected with the large outcrop occurring some 8 chains to the northward on the ridge overlooking Soldier Creek. Close to the township of Soldiers several small seams having a westerly dip of about 45° were formerly worked; but as the workings, which were approached by dips and shafts, have collapsed, and as no outcrops are visible, the writer has nothing to add to Cox's statements.†

The strike of the coal-outcrops mentioned above varies from north-north-east to north-east, and the dips, except where the structure is affected by fault-movements, are from 15° to 25° to the north-westward. No doubt as the seams are more extensively worked many of the outcrops will be linked up, and definite information concerning the extent and number of the seams will be obtained. With the data at present available it may be stated that two seams occur in the Boatman district, and that there is no necessity to postulate the existence of more than three seams to explain all the outcrops between the Waitahu River and Reefton, although between these points the gentle undulations and numerous small cross-faults render some of the correlations doubtful.

In the Boatman's area the lower seam, which supplies the large fault-involved outcrops of Howell's claim and Burk Creek, is 21 ft. thick in Coal Creek, 12 ft. to 16 ft. thick in Archer's mine, and at Capleston is reduced to 4 ft. to 5 ft. of carbonaceous claystone. The upper seam averages at least 12 ft. in Archer's property and as much in Coghlan's, while on the south side of the creek at Capleston it is 7 ft., and is only 2 ft. in Flower Creek. In the Burke Creek basin the lowest seam in each section occurring close to, but at a variable distance from, the basement rock may be safely correlated. In Madman Creek there is 20 ft. of coal, in Stony Batter Creek the seam is very large, and in Burke Creek the outcrops show from 20 ft. to 24 ft. of coal both

* Rep. Geol. Expl. during 1874–76, No. 9, 1877, p. 78. † *Ibid.*, p. 79.

on the east and on the west side. Probably also the large lower seam in the Reefton Town Belt belongs to the same horizon. Similarly in the Burke Creek basin the outcrop worked by Morris and Leishman and that first opened by Lockington may be correlated with those worked in Stony Batter Creek. The middle 5 ft. seam of this latter creek may well be the smaller seam of the Reefton Town Belt and the lower outcrop on Morris and Learmont's tram. Whether the three seams exposed on the north bank of the Waitahu belong respectively to the same horizons as the three in Burke Creek cannot at present be determined, but the writer regards it as highly probable.

From time to time samples from the numerous outcrops have been analysed in the Dominion Laboratory. It is often impossible to state definitely the seam or even the locality from which these samples were obtained, and in such cases the analyses are not quoted.

Analyses of Coals of the Reefton Group.

No.	Locality.	Fixed Carbon.	Volatile Hydro-carbons.	Water.	Ash.	Sulphur.	Remarks.
1	Boatman's Creek (probably at township)	56·98	31·37	9·57	2·18	..	Evap. power, 7·40 lb.
2	Coal Creek (Billet's mine, near Capleston)	57·15	31·25	9·46	2·14	..	Evap. power, 7·43 lb.
3	Burk Creek (Howell's claim) ..	50·00	38·90	10·25	0·85	2·60	
4	Coal Creek (Archer's mine) ..	49·85	41·02	7·66	1·47	2·70	Lower seam 16 ft.
5	Coal Creek (Archer's mine) ..	48·21	43·69	6·38	1·72	3·81	Upper seam 10 ft.
6	Coal Creek (Archer's mine) ..	44·92	46·74	5·26	3·08	6·21	Coke hard and dense ; 12 ft. seam.
7	Capleston (Archer's mine) ..	45·61	45·26	6·26	2·87	5·70	7 ft. seam.
8	Waitahu	45·08	38·76	9·64	6·52	2·76	2 ft. seam.
9	,, ...	46·06	42·93	10·24	0·83	..	Forms coherent coke ; 6 ft. seam.
10	,, ...	42·24	47·13	6·21	4·42	4·80	Hard compact coke ; 6 ft. seam.
11	,, ...	42·20	45·78	10·19	1·80	..	Hard coke ; 14 ft. seam.
12	Madman Creek	46·60	43·32	8·87	1·21	..	Hard coke ; upper seam.
13	,, ...	47·39	46·01	5·30	1·30	2·39	Upper seam.
14	,, ...	47·67	42·06	7·77	2·50	1·76	Upper seam.
15	,, ...	49·07	41·59	8·24	1·10	0·63	Lower seam.
16	Stony Batter Creek	40·20	28·91	10·43	20·46	..	10 ft. seam.
17	,, ...	42·39	46·82	9·81	0·98	..	8 ft. seam.
18	,, ...	59·99	29·77	9·43	0·81	..	Outcrop.
19	,, ...	40·10	32·99	9·93	16·98	2·87	5 ft. seam.
20	,, ...	48·51	40·80	9·70	0·99	1·59	14 ft. seam.
21	,, ...	42·42	49·20	7·28	1·10	3·89	14 ft. seam ; 6,958 calories per gramme.
22	,, ...	42·85	50·50	5·66	0·99	3·70	Form firm cokes.
23	,, ...	46·00	41·81	9·80	2·39	4·39	
24	,, ...	47·05	41·20	10·97	0·78	0·94	
25	,, ...	47·26	41·13	9·97	1·64	0·86	
26	Burke Creek (Lockington's mine)	47·84	40·83	10·22	1·11	0·79	20 ft. seam.
27	Burke Creek (Reefton Coal Company)	59·54	30·93	9·07	0·46	..	
28	Burke Creek (New Durham) ..	54·09	37·64	4·36	3·91	..	
29	Burke Creek (Dudley) ..	48·10	35·88	14·21	1·81	..	
30	Burke Creek (New Durham) ..	46·46	32·70	15·63	6·21	..	4 in. seam.
31	Burke Creek	43·82	43·85	10·12	2·21	..	8 ft. seam.
32	,, ...	40·63	48·20	9·19	1·98	..	12 ft. seam.
33	,, ...	53·87	29·69	10·23	6·21	..	10 ft. seam.
34	Devil Creek (Kearn's mine) ..	38·38	45·86	9·26	6·50	1·51	8 ft. seam ; sp. gr. 1·32.

References.

1, 2. Lab. Rep. No. 22, 1887, p. 38.
6. Lab. Rep. No. 40, 1907, p. 57.
9. Lab. Rep. No. 28, 1894, p. 6.
10. Lab. Rep. No. 40, 1907, p. 57.
11, 12. Lab. Rep. No. 28, 1894, p. 6.
13. Lab. Rep. No. 44, 1911, p. 9.
16. Lab. Rep. No. 28, 1894, p. 6.
21. Lab. Rep. No. 42, 1908, p. 6.
22–25. Lab. Rep. No. 48, 1915, p. 15.
27. Lab. Rep. No. 10, 1875, p. 10.
28, 29. Lab. Rep. No. 19, 1884, p. 23.
30. Lab. Rep. No. 22, 1887, p. 38.
31–33. Lab. Rep. No. 28, 1894, p. 6.

In the neighbourhood of Capleston the seams have both roof and floor of sandstone or grit, usually with a few inches of shale intercalated next the coal. Farther south the containing beds are finer in grain, and both roof and floor generally consist of shale or shaly sandstone. Beds of fireclay several feet in thickness overlie the 5 ft. seam on the north bank of the Waitahu, and the thick seam worked at Madman and Stony Batter creeks, and underlie the seam lowest in the sequence outcropping in the latter stream.

Plateau Group.

Under this heading is included all the fragments of the once continuous sheet of Oamaru coal-measures that covered the Reefton plateau to the base of Victoria Range on the east and overlapped the flanks of Mount Kirwan on the north. Only small fragments now remain, isolated and protected from denudation by crustal movements. Southward of Merrijigs Hill the rocks have been entirely removed. The most important coal-bearing areas are the Murray-Lankey creeks area, Merrijigs area, Rainy Creek area, and, largest of all, the Garvey Creek - Kirwan Hill area. In addition there are at least three very small coal-bearing patches on Globe Hill, and several others on the hills lying between the Rainy Creek and Deep Creek areas and the Inangahua River.

The first coal won in the Reefton district was mined from the Murray Creek seams to supply fuel to the Ajax battery. This was late in 1870. The seams from this small area still yield, after many years, a larger annual output than those of any other area in the Reefton district. In the early days each lode-mining company in the vicinity had a small coal lease from which it obtained its fuel as required. Such were the Westland, Ajax, Golden Fleece, Energetic, Golden Treasure, Phœnix, Inglewood, and Venus. The various coal leases were gradually grouped, until at present only three pits are working, known as Moyle's, Knight's, and Billet's. The Lankey Creek area, which is continuous with that of Murray Creek, was first worked in 1874, and has been constantly though irregularly worked by various owners. Some years ago it was acquired by the Progress Mines, and from it the fuel required for their smelting plant was obtained. The property was later transferred to the Consolidated Goldfields, and is worked to furnish fuel to the winding and compressing plant at the Energetic shaft.

The seams at Rainy Creek were first opened in 1876 to supply the boilers of the Rainy Creek battery, and this pit was again worked by the Supreme Company in 1888, in which year also the Inkerman Company acquired a lease. The most active mining in this locality was during the early years of the century, when the Inkerman Combined Mines were at work. With the closing-down of that gold-mine coal-winning entirely ceased.

Coal-mining in the Merrijigs area was commenced in 1888 to supply the boilers of the Union battery. Work soon ceased, however, and it may be stated that the demand for coal is entirely dependent on the requirements of the lode-mines of the vicinity. Of these the Progress has been by far the largest consumer. Two pits were at work at the time of the writer's visit in 1914—that in the basin of Slab Hut Creek originally opened by the Sir Francis Drake Company, and that in the Progress Creek owned at different times by Breen, Loughnan, Billet, and Kearns.

The Deep Creek area was first attacked by the Cumberland Company, of which the mine was situated close to its battery. This pit was closed in 1895 when that mine ceased to yield ore. Quite recently the Big River Company has opened a pit near the head of Golden Lead Creek, and supplies the requirements of its winding and compressing plant therefrom.

Up to the present no attempt has been made to work or prospect the seams of the Garvey Creek - Mount Kirwan area.

In the Murray Creek - Lankey Creek area two seams exist which exhibit very variable thickness. At Lankey Creek, where the beds are relatively undisturbed and lie fairly flatly, the lower of these may average 9 ft., while the upper is about 4 ft. thick. At Murray Creek the seams are very much thicker: thus in Knight's mine the seams are 26 ft. and 22 ft. thick, and are separated by about 6 ft. of dirty coal; at Moyle's mine, which lies on the saddle towards the Waitahu fall, one seam only was seen, 10 ft. in thickness. The reason for this rapid variation may be that the seams overlie a great fault-zone certainly older than themselves. Along this zone irregular depressions would tend to be formed by erosion, and in them the vegetable accumulations would vary much in thickness.

ANALYSES OF COALS OF THE PLATEAU GROUP.

No.	Locality.	Fixed Carbon.	Volatile Hydro-carbons.	Water.	Ash.	Sulphur.	Remarks.
1	Murray Creek	53·96	35·87	8·18	1·99	..	..
2	Murray Creek (Golden Treasure Mine)	59·22	30·17	9·60	1·01	..	22 ft. seam.
3	Murray Creek (Trennery's mine)	52·83	33·15	9·61	4·40	..	22 ft. seam.
4	Murray Creek (Phœnix Mine) ..	56·18	32·24	9·61	1·97	..	25 ft. seam.
5	Murray Creek (Knight's mine) ..	50·43	43·12	5·20	1·25	0·42	7,214 calories per gramme.
6	Murray Creek (Moyle's mine) ..	52·11	43·74	2·72	1·43	1·02	Coal crushed and tender.
7	Lankey Creek	51·76	37·26	10·19	0·79	..	..
8	,, ...	58·01	33·29	6·79	2·01	..	Cokes well.
9	,, ...	56·01	31·79	6·15	4·05	..	12 ft. seam.
10	,, ...	51·05	40·40	6·60	1·95	2·05	7 ft. seam; 6,940 calories per gramme.
11	Merrijigs	46·67	43·51	7·61	2·21	4·66	5 ft. solid coal; sp. gr. 1·29.
12	Big River Mine	52·51	39·94	3·35	4·20	0·41	Crushed coal.
13	Garvey Creek	48·82	44·17	4·08	2·93	2·36	4 ft. solid coal.

References.

1. Lab. Rep. No. 19, 1885, p. 23.
2–4. Lab. Rep. No. 22, 1887, p. 38.
5. Lab. Rep. No. 40, 1907, p. 57.
7. Lab. Rep. No. 18, 1883, p. 42.
8. Lab. Rep. No. 19, 1885, p. 23.
9. Lab. Rep. No. 22, 1887, p. 38.
10. Lab. Rep. No. 40, 1907, p. 57.

In the Rainy Creek area only one seam appears to be developed. Where worked by the Inkerman Company this was from 5 ft. to 6 ft. thick, and dipped eastward at 60°. The Supreme Company's claim was at a higher level, and there the seam was about 8 ft. thick and nearly horizontal. On the Big River Road a tunnel was driven by the Industry Company to prospect an auriferous lode. Before reaching the lode-bearing greywacke this passed through a 3 ft. seam of coal, dipping at about 45° to the eastward.

The Deep Creek area is similar in structure to that just described, being involved along the same fault-zone. The seam, however, here seems to be rather thicker, and where worked by the Cumberland Company showed from 11 ft. to 16 ft. of clean coal, rather crushed and dipping steeply to the westward. At the Big River Mine the seam appears to lie nearly horizontally, is from 10 ft. to 16 ft. thick, but has been so crushed by earth-movements as to yield practically only slack coal.

The Merrijigs area has also been very detrimentally affected by faulting. A patch of relatively flat-lying solid coal occurs between the heads of Progress, Slab Hut, and Fossicker creeks. Even this small area is traversed by faults, and a good deal of exceedingly crushed coal has been mined from the eastern side of Progress

Creek. Where solid the coal is from 5 ft. to 6 ft. thick, but near the old Inkerman shaft only 2 ft. outcrops. In the abandoned Progress Coal-mine the pulped coal was from 1 ft. to 10 ft. thick. In the old Sir Francis Drake Coal-mine, which lies a few chains south of Slab Hut Creek, and now supplies part of the demands of the Progress Mines, the coal is highly crushed, and reaches a thickness of 12 ft.

The Garvey Creek - Mount Kirwan area covers several square miles, and is decidedly less affected by faults than any other area of the group. Very little is known concerning the coal-seams it may contain, and only one outcrop has been examined; this was of a 4 ft. seam occurring in upper Garvey Creek. The strata in the vicinity were undisturbed, and had a westerly dip of about 10°. Coal 6 ft. thick is reported to outcrop in several of the small streams draining from the hills a little south of Garvey Creek, and in one of them coal-fragments were observed. McKay* in 1874 noted the occurrence of a seam of coal of unknown thickness and apparently good quality, and dipping eastward at less than 50°, about two miles down-stream from the Waitahu forks. This was not observed by the writer. Mr. W. Kirwan states that a large fault-involved coal-outcrop occurs in the creek immediately to the west of Kirwan Creek, and in the same locality coaly material is reported to exist at the base of the grits lying to the west of Trigonometrical Station Z. This is doubtless a similar occurrence to the crushed coal found on the Mount Kirwan Track near the saddle between Topfer and Boatman creeks.

There are on record many analyses of samples of the coals of this group, but these are chiefly from the seams of Murray and Lankey creeks. No doubt the crushing and heating of the coal through earth-movements have influenced its composition. But even where there is no indication of faulting the seams contain coal of a decidedly higher grade than that of the seams of the Reefton group, with which they are very closely connected, and of which at one time they may possibly have formed a part.

Waiwhero Group.

That a coal-bearing horizon underlies the Cobden limestone in the district between the lower Punakaiki and Barrytown is shown by the thick outcrop of coal occurring in Waiwhero Creek. This was not visited by the writer, but he was informed that the coal was 20 ft. in thickness, dipped steeply to the westward, and was a clean, hard, brown coal. On theoretical grounds it is probable that the coal-seams of this locality will exhibit decided lenticularity, and that the most productive area will lie in the middle basins of the Porarari and Punakaiki rivers.

Garden Gully Group.

This group is situated in the Moonlight Creek basin, and contains only two small patches of coal-bearing rock separated by the valley of McCarthy Creek. The large seam outcropping in Fitzgerald Creek has been worked open-cast to a limited extent to supply fuel to the Moonlight dredge. The coal was transported to the foot of the creek by means of a sluice-box, and thence carted to the dredge.

In this locality a seam 24 ft. thick stands vertically between Palæozoic greywacke on the one side and soft green sandstone of Oamaru age on the other. In the area to the north and in the basin of Garden Gully a thick seam outcrops for several chains at the old township, and again in a small tributary farther up-stream. The coal is here horizontally disposed, and rests on rather incoherent grit and quartz conglomerate about 20 ft. above rotten greywacke. The seam is overlain by soft, blue,

* Rep. Geol. Expl. during 1873–74, No. 8, 1877, p. 94

argillaceous sandstone. Another thick outcrop occurs at a higher level, on Jenkin's water-race; but probably only one seam is present, the difference in elevation being due to fault-movements.

The coal is of the composition shown in the appended table :—

	(1.)	(2.)	(3.)	(4.)
Fixed carbon	34·49	35·60	35·00	34·39
Volatile hydrocarbons ..	48·51	46·63	47·07	43·84
Water	16·35	17·17	17·11	19·45
Ash	0·65	0·60	0·82	2·32
	100·00	100·00	100·00	100·00
Sulphur	4·82	4·69	3·07	4·54
Specific gravity	1·20	1·19	1·16	1·23

(1.) Upper 12 ft. of seam, Fitzgerald Creek.
(2.) Lower 12 ft. of seam, Fitzgerald Creek.
(3.) Thick seam, Jenkin's water-race, Garden Gully.
(4.) 20 ft. seam, township, Garden Gully.

Brighton Group.

The thick seam underlying part of Welshman Terrace near Brighton was probably discovered soon after the gold "rush" to that place, and an analysis of the coal from this seam was made in 1866. The coal has been mined to a slight extent for household purposes, and has also been used by the small steamers that at one time traded to Brighton.

About 80 ft. above sea-level a seam 8 ft. thick occurs in the face of the sea-cut terrace about half a mile north of the mouth of the Fox River. The same seam, this time about 30 ft. above sea-level, shows near the base of a bluff on the north bank of the Fox River about 100 chains from its mouth. The coal varies here from 5 ft. to 8 ft. in thickness, and is underlain by rather incoherent grit containing irregular carbonaceous material, and overlain by soft sandstone and sandy claystone, followed by limestone of Oamaru age. In both localities the seam may be 20 ft. to 50 ft. above the underlying Mawheranui beds. On Francis's farm, about three miles south of the Fox River, a coal-seam 16 ft. thick, diminishing half a mile southward to 5 ft., outcrops at several points along the flank of the hills at about 320 ft. above sea-level. As far as could be observed, the containing beds were similar to those farther north, and the seam is certainly on the same horizon, if not actually continuous, with that of the Fox River. Probably outcrops connecting those already known will be discovered in the future. On the foothills of the Paparoa Range north of Bullock Creek is a small patch of coal-bearing strata containing seams up to 8 ft. in thickness. The rocks are involved, together with breccia conglomerate of Mawheranui age, in a great fault-zone, one seam actually appearing to dip beneath the gneissic granite of the mountains. The writer did not visit these outcrops, and the area may belong either to the Oamaru Series (as mapped) or to the older bituminous coal-measures. The seams have no commercial value.*

In the writer's opinion, the prospect of obtaining seams of considerable areal extent are decidedly more favourable in this area—which was, during early Oamaru times, sheltered from the full force of the waves by the granite headland now forming Gentle Annie Rocks—than in the Waiwhero area.

* See N.Z. G.S. 5th Ann. Rep., 1911, C.–2, p. 12.

[*Photo by W. Sherlock.*

PLATE XI.—OUTCROP OF COAL-SEAM, GILES CREEK, Coal forms the whole of the solid outcrop.

Face p. 217.]

The following table includes all published analyses :—

	(1.)	(2.)	(3.)	(4.)	(5.)
Fixed carbon	41·08	34·26	29·48	34·12	35·45
Volatile hydrocarbons	26·92	31·76	48·64	43·90	44·49
Water	21·54	20·18	17·36	15·61	16·32
Ash	10·46	13·80	4·52	6·37	3·74
	100·00	100·00	100·00	100·00	100·00
Sulphur	..	..	5·65	5·51	0·59
Specific gravity	..	..	..	1·34	1·26

(1.) Lab. Rep. No. 2, 1867, p. 16. Probably from Welshman Terrace.
(2.) Lab. Rep. No. 29, 1894, p. 5. Welshman Terrace.
(3.) Lab. Rep. No. 45, 1911, p. 9. Brighton.
(4.) From seam 100 chains up Fox River.
(5.) From 16 ft. seam on Francis's farm.

Giles Creek Group.

In Giles Creek two very large outcrops of coal-seams belonging to the Pareora Series occur. The first, which is about two miles and a half above the junction of that stream with the Inangahua, shows two seams striking a little east of north, dipping 30° to the eastward, and separated from one another by about 12 ft. of sandstone and shale. The upper, which is overlain by carbonaceous mudstone, shows 8 ft. of coal with two partings. The lower is at least 30 ft. thick, although the floor was not observed, and has a thin parting about 5 ft. from the roof. These seams may be traced for about 10 chains along the rill that joins the main stream just above the outcrop, and large lumps of coal occur in a rill about 20 chains to the northward. About a mile and a half farther up-stream another very large outcrop may be observed, but here neither roof nor floor can be seen.

Whether these outcrops belong to the same seam or to different seams of the same horizon the writer would hesitate to say. The coal is hard and tough, and has the following composition :—

	(1.)	(2.)
Fixed carbon	39·16	39·12
Volatile hydrocarbons	40·63	40·42
Water	18·46	17·16
Ash	1·75	3·30
	100·00	100·00
Sulphur	0·41	0·20

(1.) From the upper outcrop. Analysis made by the writer in 1908.
(2.) From the lower outcrop. Lab. Rep. No. 44, 1910, p. 8 (there referred to Stony Creek).

Camp Creek Group.

There are a great number of outcrops of coal in both branches of Camp Creek, a small tributary of Brown Stream, which itself flows to the Inangahua. Several folds and faults are undoubtedly present, and probably not more than three or four seams actually exist. The seams vary up to 20 ft. in thickness, are very lenticular, and tend to grade into carbonaceous claystone most irregularly. In all, eight samples were taken—four from each branch—but as the composition of the coal calculated on an ash-free basis shows but little variation, the position from which each sample was taken need not be more precisely designated. The coal-outcrops which occur in lower Coal Creek (tributary of the Inangahua), and of which a thickness of 3 ft. only was observed, undoubtedly belong to the same series of seams as are developed in Camp Creek. The containing beds are similar in appearance, and the structure in both areas is essentially the same—namely, a dip of about 30° to the south-east.

Quite close to the base of the Brunner Range the same beds, which are considered to be of Pareora age, occur, and also contain coal-seams at several points. In Dee Stream the seams outcrop in three sets, of which both the lowest and the highest exhibit three seams, each about 3 ft. in thickness, and separated by conglomerate and claystone. The middle outcrop shows 4 ft. of coal. All the seams dip eastward at angles of from 30° to 70°. In Rough Creek two thin seams, separated by claystone containing excellent leaf-impressions similar to those of Camp Creek, are found, the dip being 50° to the south-east. In Dunphy Creek, the main branch of the Landing Stream, are coal-seams 18 in. and 4 ft. thick respectively, interbedded with claystone, grit, and conglomerate. They strike nearly north and south, and dip about 75° to the westward.

Analyses of coal from some of the outcrops mentioned are as follows :—

Locality.	Fixed Carbon.	Volatile Hydro-carbons.	Water.	Ash.	Sulphur.	Remarks.
Right-hand branch of Camp Creek	40·37	39·11	19·18	1·34	0·63	Sp.gr. 1·30.
	41·11	37·52	20·04	1·33	0·63	Sp.gr. 1·32.
	38·57	38·07	20·43	2·93	0·65	Sp.gr. 1·33.
	34·88	37·57	17·73	9·82	5·06	Sp.gr. 1·36.
Left-hand branch of Camp Creek..	36·07	37·89	19·32	6·72	2·25	
	38·71	38·02	19·92	3·35	0·65	
	39·36	39·21	19·19	2·24	0·70	
	32·88	35·49	16·47	15·16	1·43	Sp.gr. 1·42.
Dee Stream (lowest outcrop) ..	39·48	41·46	14·89	4·17	2·92	5,969 calories per gramme.
Rough Creek	43·23	37·70	17·05	2·02	0·93	Sp.gr. 1·34.
Dunphy Creek	34·29	48·39	15·54	1·78	1·92	Forms soft coke ; 18 in. seam.
Dunphy Creek	33·80	49·62	15·28	1·30	2·31	Forms soft coke ; 4 ft. seam.

Ultimate Analyses.

The following ultimate analyses of coals from the Oamaru Series have been made in the Dominion Laboratory :—

—	Felix Creek. No. 9 (page 206).	Capleston. No. 4 (page 212).	Capleston. No. 5 (page 212).	Madman Creek. No. 14 (page 212).	Stony Batter Creek. No. 20 (page 212).
Carbon	60·89	67·16	67·16	66·91	66·44
Hydrogen	6·19	6·74	6·56	6·45	6·44
Nitrogen	0·84	0·59	0·56	0·60	0·70
Oxygen	25·98	21·34	20·19	21·78	23·84
Sulphur	2·65	2·70	3·81	1·76	1·59
Ash	3·45	1·47	1·72	2·50	0·99
Calorific value (from ultimate analyses)	5,993	6,889	6,904	6,730	6,596

Output of Coal.

Fairly complete statistics of the production of coal from the various mines of the Reefton Subdivision have been regularly published by the Mines Department since

1879, as well as total approximate outputs prior to that date. The following table compiled from the Mines Reports shows the production from various areas with as great a degree of completeness as the case admits of:—

Production of Coal-mines of the Reefton Subdivision.

——	Buller Gorge.	Three-channel Flat.	Boatman Creek.	Burke Creek.	Reefton.	Devil Creek.	Merrijigs.	Inkerman.	Murray Creek.	Deep Creek.	Total Annual Output.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Prior output	..	..	300	166	..	2,000	..	..	5,500	..	7,966
1879 ..	..	..	300	20	..	300	..	..	1,612	..	2,232
1880 ..	..	..	230	31	..	360	..	..	2,480	..	3,101
1881 ..	..	..	400	170	..	..	..	..	1,432	..	2,002
1882 ..	..	..	346	600	..	240	..	..	1,641	..	2,827
1883 ..	..	..	524	349	..	200	614	..	1,646	..	3,333
1884 ..	20	..	308	6	..	..	..	..	1,017	..	1,351
1885 ..	..	..	181	..	..	..	..	1,000	1,130	..	2,311
1886 ..	..	..	244	..	..	..	..	340	2,225	..	2,809
1887 ..	6	..	538	..	..	..	..	..	1,242	..	1,786
1888 ..	..	..	172	..	..	..	480	..	2,603	..	3,255
1889 ..	..	..	159	..	..	..	400	300	2,162	..	3,021
1890 ..	..	..	450	..	..	..	1,330	500	3,730	..	6,010
1891 ..	137	..	480	..	..	155	775	330	2,816	..	4,693
1892 ..	36	..	222	..	..	259	1,134	231	2,222	300	4,404
1893 ..	101	..	310	410	..	..	1,420	..	1,594	480	4,315
1894 ..	100	..	300	370	40	..	1,701	..	1,981	200	4,692
1895 ..	..	230	300	..	..	..	1,839	..	2,089	90	4,548
1896 ..	400	..	315	..	..	..	874	..	2,006	..	3,595
1897 ..	55	..	..	..	..	..	..	240	2,625	..	2,920
1898 ..	12	..	..	688	..	40	516	355	3,065	..	4,676
1899 ..	25	160	..	581	..	..	1,276	154	2,466	..	4,662
1900 ..	..	568	..	1,197	..	..	1,256	405	1,621	..	5,047
1901 ..	837	391	800	1,453	..	..	1,960	520	1,369	..	7,330
1902 ..	1,469	500	1,740	1,216	..	..	2,179	581	3,044	..	10,729
1903 ..	2,298	800	2,080	362	228	..	2,120	1,450	3,943	..	13,281
1904 ..	2,090	1,139	2,008	164	750	..	2,397	2,400	3,971	..	14,919
1905 ..	1,043	1,249	2,071	764	228	..	3,181	500	3,699	..	12,735
1906 ..	1,062	1,533	1,956	418	515	..	2,957	..	5,210	..	13,651
1907 ..	1,036	699	1,282	1,228	1,142	..	3,268	..	3,829	..	12,484
1908 ..	806	460	1,222	1,642	726	..	2,801	..	3,037	..	10,694
1909 ..	819	366	1,462	1,573	366	73	2,470	..	3,373	..	10,502
1910 ..	549	..	1,179	2,341	130	135	3,588	..	6,529	..	14,451
1911 ..	446	..	1,764	3,677	..	540	2,730	..	4,739	..	13,896
1912 ..	315	..	2,219	4,050	197	510	1,313	..	2,757	..	11,361
1913 ..	123	..	926	4,834	1,463	327	2,103	..	4,055	..	13,831
1914 ..	114	..	204	3,683	455	..	2,165	..	3,802	832	11,255
Totals ..	13,899	8,095	26,992	31,993	6,240	5,139	48,847	9,306	104,262	1,902	256,675

OTHER DEPOSITS OF ECONOMIC VALUE.

Clays and Claystones.

The upper and lower beds of the Greymouth Series consist to a great extent of claystone-layers, some of which are probably well adapted for the manufacture of bricks, tiles, &c., while some if mixed with limestone would without doubt be suitable for the production of cement. Many of the beds, however, are too sandy for these purposes. These claystones differ in no essential feature from those of similar age in the adjoining subdivisions, and their chemical composition may be judged from the analyses given in Bulletin No. 13, page 95, and Bulletin No. 17, page 129. The deposits of Pleistocene age contain a considerable proportion of clayey material, but the admixture of sand and gravel is nearly always considerable. Recent clays, either residual or transported, are not abundant. The sandy clays of Liverpool Dave and Soldier creeks, near Reefton, have been derived from the much decomposed Tertiary breccia that occupies a small area in this neighbourhood. They have been used to a small extent for brickmaking. Deposits of silt, which in the North Blackwater shaft were 80 ft. thick, occur in the vicinity of Waiuta and at various points over the plateau country between the Inangahua and the Big Grey rivers. A similar but small deposit occurs above Crushington, where it is exposed in the old Globe race and again on a low terrace near Lankey Creek. This material, which is always light-coloured, is probably a glacial silt or rock-flour rather than a true clay. A pure-white sample from near Crushington had the following composition :—

Silica (SiO_2)	71·4
Alumina (Al_2O_3)	17·9
Iron oxides (Fe_2O_3, &c.)	1·4
Lime (CaO)	0·3
Magnesia (MgO)	0·7
Water and organic matter	5·7
Alkalies and undetermined	2·6
	100·0

Dr. Maclaurin remarks that this material "might prove suitable for certain classes of fire-goods."*

Little fireclay is associated with the coal-seams of the Reefton Subdivision. The only beds noted by the writer occur in connection with the seams of the Burke Creek group, where the fireclay underlies and overlies the coal indifferently. Test firebricks were made at Brunner of material from this locality some years ago. The following analyses of the clays are available :—

——	(1.)†	(2.)†	(3.)‡	(4.)‡	(5.)	(6.)
Silica	58·90	43·10	62·07	60·40	49·87	53·15
Titanium dioxide ..	..	..	..	..	1·14	1·60
Alumina	22·10	25·80	20·14	21·86	30·09	38·17
Iron oxide	3·80	1·70	2·17	2·26	2·64	1·84
Lime	1·00	0·90	0·15	0·10	Nil	0·60
Magnesia	0·60	0·70	0·85	0·53	1·36	0·99
Alkalies	..	1·90	3·05	2·83	4·80	4·22
Water at 100° C. ..	12·00	25·90	1·17	1·27	1·46	Nil
Combined water and organic matter			10·28	10·90	8·21	Nil
Undetermined	1·60	..	..	..	..	..
	100·00	100·00	99·88	100·15	99·57	100·57

† Lab. Rep. No. 40, 1907, p. 13. ‡ Lab. Rep. No. 48, 1915, p. 17.

The first five analyses represent samples from seams in Stony Batter Creek, No. 5 being from a thick layer below the coal-seam outcropping farthest up the stream. No. 6 is from a bed at least several feet thick overlying the 20 ft. seam worked by Morris and Learmont in Madman Creek. The sample contained 43·17 per cent. of organic matter and water, which was burnt off, and the analysis is of the residue. These clays, though not of the highest quality, should prove of considerable value.

* 40th Ann. Rep. Col. Lab., 1907, p. 13.

Alum Shale.

Between the main branches of Lankey Creek a thick layer of Devonian mudstone is overlain by a quartz conglomerate of Tertiary age. The conglomerate contains much iron sulphide, apparently in the form of marcasite, and this is also present, but not nearly so abundantly, in the mudstone. The conglomerate is mined for its detrital gold, and in the operation a considerable amount of the argillaceous rock is also removed. When exposed to the weather this breaks up, and quickly becomes coated with a white efflorescence consisting of soluble sulphates of aluminium and iron. Analyses of this material gave the following results* :—

Aluminium sulphate ($Al_2\,3(SO_4)\,18H_2O$)	8·29	5·94
Ferrous sulphate ($FeSO_4\,7H_2O$)	6·02	5·49
Silica (SiO_2)	51·63	65·64
Alumina (Al_2O_3)	20·61	12·96
Iron oxides (Fe_2O_3, &c.)	2·46	1·05
Iron sulphide (FeS_2)	2·66	3·45
Lime (CaO)	0·08	0·17
Water and organic matter	7·75	3·93
Undetermined	0·50	1·37
	100·00	100·00

Dr. Maclaurin* remarks that the material is of good quality, agreeing in composition with the well-known and extensively worked alum shales of Yorkshire. He doubts, however, whether alum could be made at a profit, owing to the high cost of necessary potash salts and of labour.

Limestone.

Limestone of Tertiary age is abundant in the Reefton Subdivision, but it is frequently too impure to be of value for commercial purposes. Enormous quantities of good-quality limestone exist in the coastal region, but these deposits are at present difficult of access. In the Inangahua valley limestone covers a considerable area on the eastern flank of the Paparoa Range, from Fletcher Creek northward to Inangahua Junction and thence down the Buller to Berlin's. Thick layers of high-grade rock occur, but usually the limestone contains a considerable proportion of clayey matter, and is suitable for the manufacture of cement rather than for the production of quicklime. Analyses Nos. 4 and 5 below are of rocks that have very nearly the composition of a cement stone, while a mixture of a " fat " limestone such as No. 1 and a calcareous claystone like No. 6 would also produce an excellent Portland cement. Ample supplies for all purposes of material having similar composition are available.

A quarry was opened in Devonian limestone, on the main road about a mile above Crushington, to supply limestone for the smelting charge of the Progress concentrates. Owing to the early suspension of smelting little rock was used for this purpose. Mr. Thomas Watson has burnt this limestone in a kiln successfully, and has used the product with highly satisfactory results on his farm in the upper Inangahua valley, opposite the junction of Rainy Creek. A sample taken by the writer from this quarry

* Lab. Rep. No. 40, 1907, p. 18.

was found to contain 84·81 per cent. of carbonate of lime. Analysis No. 3 below also represents a sample from the Devonian limestone of this locality.

—	(1.)	(2.)	(3.)	(4.)	(5.)	(6.)
Silica (SiO_2)	1·70	6·36	7·55	13·20	14·15	47·55
Titanium dioxide (TiO_2) ..	..	..	..	..	n.d.	0·98
Alumina (Al_2O_3)	0·17	1·59	2·12	1·92	3·00	19·36
Ferric oxide (Fe_2O_3) ..	0·36	..	..	..	1·28	7·80
Manganous oxide (MnO) ..	0·06	..	..	..	n.d.	n.d.
Lime (CaO)	53·42	50·78	48·70	46·07	43·62	4·18
Magnesia (MgO)	0·53	0·82	0·85	0·24	0·71	1·84
Phosphorus pentoxide (P_2O_5)	0·51	0·05	0·25	0·26	n.d.	n.d.
Carbon dioxide (CO_2) ..	42·36	39·60	38·50	35·70	33·96	4·00
Soda (Na_2O) .. / Potash (K_2O) ..	0·26	0·24	1·03	1·36	0·71	0·98 / 2·16
Water and organic matter ..	0·54	..	1·00	1·25	2·57	11·30
Totals	99·91	100·00	100·00	100·00	100·00	100·15

(1.) Purest band of limestone in gorge, Hunt Creek, Reefton Survey District.

(2.) Totara Flat, 46th Ann. Rep. Dom. Lab. 1913, p. 14. (Sample may have been taken from small outcrop in Fitzgerald Creek, Waiwhero Survey District.

(3.) Crushington, 46th Ann. Rep. Dom. Lab., 1913, p. 14. Devonian limestone.

(4.) Inangahua, 46th Ann. Rep. Dom. Lab., 1913, p. 14. (Sample probably obtained from basin of Fletcher Creek.)

(5.) Average argillaceous limestone below gorge, Hunt Creek, Reefton Survey District.

(6.) Calcareous claystone, Buller Gorge Road, east of Coal Creek, Inangahua Survey District. Bull. No. 17, 1915, p. 129.

Building-stones.

Granite occurs in great abundance, forming the main portion of the Paparoa, Victoria, and Brunner ranges, and can furnish an inexhaustible supply of building-material. There are several well-marked varieties, of which perhaps the most ornamental is the pink granite through which McMahon Creek (a small branch of the Te Wharau) has cut its way. Grey granites are far more abundant, a beautiful medium-grained variety occurring on the flanks of Mount Gore. Mount Albert is composed largely of a fine porphyritic rock, while the road through the Inangahua valley in this locality (Waitahu Survey District) exposes a dense brownish-grey rock of pleasing appearance.

The greywackes of the Aorere Series have been quarried for large stones for use in river-protection works. They are hard and tough, but their irregular jointing would cause the production of much waste material.

Crinoidal, coralline, and shell marbles occur among the Devonian limestones of the subdivision, and are without doubt capable of furnishing ornamental stone of great beauty. Unfortunately, the thinness of the various layers, combined with their irregular jointing, makes the chance of getting large blocks, or even a large supply of similar material, rather doubtful.

The sandstones of Tertiary age, where they readily break into slabs, have been used in building rough walls and chimneys. The quality of this stone is very poor, and its use will never be more than local.

The limestones of similar age are also generally suited only for local use. The rock in the neighbourhood of Brighton is much purer than in other parts of the subdivision, and beds of great thickness occur. The stone is fine-grained and homogeneous, and could probably be worked in a lathe or carved in *bas-relief*, and would readily take a smooth surface, and perhaps a polish. Large massive blocks could be easily obtained. White, buff, and faint-pink varieties were noted. The difficulties of transport in this out-of-the-way locality will almost certainly prevent this stone being used for many years.

Two small veins of alabaster from 6 in. to 8 in. thick were intersected in the Kirwan's Reward low-level adit, but are of no commercial value. The rocks in this locality are much shaken, and are well above ground-water level. It is likely that the alabaster was deposited in open fissures by down-seeping solutions, the sulphate of lime being probably produced by the action of sulphuric acid, derived from the oxidation of pyrite, on the greywacke.

Roadmaking-material.

Roadmaking-material is everywhere abundant in the subdivision. In the neighbourhood of Reefton greywacke is quarried for macadamizing-material, but elsewhere stream-gravels are generally used, the larger pebbles being removed or broken. Along the coast marine gravels serve the same purpose, but the smooth rounding of all the pebbles militates against the consolidation of road-surfaces made from such deposits, even when a large proportion of broken cobbles is included. The Late Tertiary schist conglomerates and the half-decomposed gravels of the Old Man Bottom Series furnish material that forms an excellent surface for light traffic.

Oil-shale and Petroleum.

Underlying the thick coal-seam worked in Stony Batter Creek is a layer of pyroshale, reported to reach sometimes a thickness of 3 ft. This burns readily, and a sample was found to contain 2 per cent. of oil. The odour of petroleum is distinctly perceptible in freshly fractured limestone from Fletcher and Flaxbush creeks and the Punakaiki River.

Platinum.

Platinum or some similar metal is reported to occur in the form of flattened grains associated with the detrital gold won by the Worksop and Boatman Creek dredges, and also in the auriferous gravels north of the Ten-mile Creek.* It is probably widespread throughout the alluvial deposits of the Inangahua and Grey valleys, but owing to the smallness and very sparse distribution of the grains they are rarely noticed. It has probably been derived from the belt of magnesian rocks traversing the main Alpine chain eastward of the subdivision, although the pyroxenite dykes of the subdivision ought also to be considered in this connection.

Arsenic and Antimony.

The mines of the Reefton district produce annually about 1,400 tons of concentrates, which are shipped either to smelters or other treatment plants in Australia. These concentrates are valued entirely according to the amount of gold they contain.

* N.Z. G.S. Bull. No. 13, 1907, p. 91.

At the Boolaroo works in Victoria the material is first roasted and the arsenical fumes condensed, while from the residues, after the extraction of the gold and grinding in berdans, a colouring-material used in the mixing of hæmatite paint is produced.

Other Metallic Sulphides.

A veinlet of galena, barely an inch in thickness and containing only 8 oz. of silver per ton, was discovered in No. 3 level of the Caledonian Mine. It cut out after being driven on for a few feet. Crystals of galena also occur in a quartz vein near the head of Moonlight Creek. The antimonial ores of the Reefton district sometimes contain lead, perhaps in combination with antimony and sulphur, as jamesonite or some other sulph-antimonide. The concentrate of the Murray Creek mines, which carries up to 7 per cent. of antimony, also contains 1 per cent. of lead, while bismuth is reported to have been detected in that from the Supreme Mine.

Several of the quartz lodes of the Paparoa area contain a little molybdenite,* and a small vein outcropping along the rill discharging to the sea half a mile south of Maukurunui Bluff was prospected for this mineral, with unsatisfactory results. A sample from a small lode in greywacke in McConnochie Creek was found to contain less than 0·05 per cent. of molybdenum, and this was the most promising-looking outcrop noted during field-work. Fragments of pegmatite containing molybdenite and chalcopyrite were found among the gravels of the Waitahu and Larry rivers.

Copper in the form of chalcopyrite seems always to be associated with molybdenite, and such ore then contains an appreciable amount of silver, but very little gold. Thus the small quartz vein in McConnochie Creek above referred to carried 1·65 per cent. of copper and over 17 dwt. of silver per ton. Chalcopyrite also occurs sparingly in the gold-bearing lodes of the Paparoa area, and still more rarely in some Reefton mines (Blackwater, Big River, and Fiery Cross). Green stains due to copper carbonate were noted in the large non-auriferous quartz lodes of Bateman Creek (Reefton Survey District) and in a joint-plane in hornfelsic greywacke in Dilemma Creek (Brighton Survey District).

Cassiterite, etc.

Cassiterite in water-worn grains has long been known to be sparingly distributed in the Lankey Creek "cements."† It has also been reported to occur in Blacksand and Ten-mile creeks‡ (Waiwhero Survey District), while a sample from Healy Gully sluicing claim, just without the subdivision, was found on analysis to contain 1·05 per cent. of tin.

Rare earths—cerium, thorium, &c.—almost certainly contained in monazite, are widely distributed throughout the subdivision. This mineral is, like zircon and garnet, probably universally present in all stream and marine gravels. Concentrate from the Moonlight dredge was found to contain 0·55 per cent. of rare earths, that from the Slab Hut dredge 2·8 per cent. (with less than 0·1 per cent of thorium),§ and that from Healy Gully sluicing claim 0·28 per cent. Monazite has also been detected in concentrates from the Merrijigs and the Lyell hydraulic sluicing claims.

Tungstic acid, probably in wolfram, was present in a sample of the Moonlight dredge concentrate (which also contained 0·67 per cent. of bismuth) to the extent of 0·77 per cent. Scheelite, almost certainly derived from veins in the mountains at the head of the Buller, occurs in the sluicing claims near that river below Lyell, and at Newton Flat, eight miles up-stream from that township. Small hand-specimens have been picked up on the river-beaches as far from their source as Inangahua Junction.

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* 31st Ann. Rep. Col. Lab., 1898, p. 21.

† 16th Ann. Rep. Col. Mus. and Lab., 1882, p. 41.

‡ N.Z. G.S. Bull. No. 13, 1907, p. 91.

§ 40th Ann. Rep. Col. Lab., 1907, p. 25.

Iron-ores.

Auriferous blacksand occurs in the present and raised sea-beaches along the coast. They consist chiefly of magnetite and ilmenite, and probably contain in small amount many of the minerals mentioned in the preceding section. Siderite occurs in small masses in connection with the diabase dyke of the Blackwater Mine Concretions of carbonate of iron containing clay and some carbonaceous matter, and showing leaf-impressions, were collected by McKay* from the bed of Garvey Creek when that stream was being worked for gold. Samples of this material are to be seen in the Reefton School of Mines. A spathic iron-ore containing 40·61 per cent. of metallic iron has also been found in Moonlight Creek.†

A small deposit of rubbly bog iron-ore outcrops on the saddle track between Painkiller Creek and the Ulster Mine. A sample of this when analysed gave the following result :—

Silica (SiO_2)	25·26
Alumina (Al_2O_3)	4·65
Ferric oxide (Fe_2O_3)	52·80
Lime (CaO)	Nil
Magnesia (MgO)	0·06
Phosphorus pentoxide (P_2O_5)	0·13
Water and organic matter	17·00
Alkalies and undetermined	0·10
	100·00
Equivalent to metallic iron	36·96

The sample of similar material analysed in 1906, and containing 43·12 per cent. of metallic iron,‡ was probably from the same deposit, which occurs on a remnant of high-level terrace at a height corresponding with that of the tablelands between the Inangahua, Waitahu, and Larry rivers. Doubtless other similar deposits exist on these terraces where they abut against a mineralized zone of greywacke, as in the above instance, or against the pyritized lower beds of the Greymouth Series. It is probable that the ferruginous clay of Liverpool Dave Creek§ is thus to be accounted for. Bog iron-ore is forming at the present time in suitable localities near the coast, the iron being derived from the deposits of blacksand so abundant in that region.

* "On the Geology of the Reefton District, Inangahua County." Rep. Geol. Explor. during 1882, No. 15, 1883, p. 148. † 30th Ann. Rep. Col. Lab., 1897, p. 14. ‡ 40th Ann. Rep. Col. Lab., 1907, p. 20. § McKay, A. : *Loc. cit.*

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